# ENGINEERING POLICY BALLOT

## Effective: July 1, 2024

# Level 2

Level two revisions require the approval of the **Assistant Chief Engineer** and the **Federal Highway Administration** only. The **Senior Management Team** is encouraged to review the content and provide comment to the appropriate director. For all other parties, these revisions are posted for information only.

# ENGINEERING POLICY BALLOT

**Effective: July 1, 2024**

## Issue 1: Inertial Profiler Certification and Dispute Resolution Requirements.

**Approval:** **Level 2 – Assistant Chief Engineer**

Sponsor: Jason Blomberg – CM

Summary: Profiler certification requirements have changed. Smoothness dispute resolutions no longer settled by the MoDOT SurPro and will require a Third Party.

Publications: Missouri Standard Specification: Sec. 610
Engineering Policy Guide: 106.3.2.59 TM-59

## Issue 2: MoDOT Guidance Update for Guard Cable.

**Approval:** **Level 2 – Assistant Chief Engineer**

Sponsor: Kaitlyn Bower – DE

Summary: MoDOT's guidance for use of guard cable has been updated to clarify low-tension references are for repairs only and all new installations will be high-tension guard cable. These revisions also include guidance for splicing both high-tension and low-tension guard cable.

Publications: Missouri Standard Specification: Sec. 606, Sec. 1040
Missouri Standard Plan: 606.41, 606.42(new)
Engineering Policy Guide: 231.1.2, 606.2, 617, 1040
JSP0607: 3 - or 4 - Strand High-Tension Guard Cable

## Issue 3: MASH Box Culvert Guardrail Attachment.

**Approval:** **Level 2 – Assistant Chief Engineer**

Sponsor: Darren Kemna – BR

Summary: Provides a MASH option for attaching guardrail to box culverts. This revision also includes guidance for Two Tube Bridge Railings.

Publications: Missouri Standard Plan: 606.50
Engineering Policy Guide: 751.1.3.4, 751.8.3.5, 751.12.2, 751.12.6, 751.50

## Issue 4: Impact Attenuators - Revisions to EPG to align with current TA guidance.

**Approval:** **Level 2 – Assistant Chief Engineer**

Sponsor: Dan Smith – TS

Summary: This clarifies usage of Impact Attenuators within Work Zones. These clarifications align with recent revisions to TAs and TMA usage.

Publications: Engineering Policy Guide: 612, 612.4, 616.23.2.5.11, 616 – Work Zone Safety and Mobility Policy Resources

## Issue 5: Updates to EPG 616.19 Missouri Quality Standards for TCC Devices version 2013 to a 2024 version.

**Approval:** **Level 2 – Assistant Chief Engineer**

Sponsor: Dan Smith – TS

Summary: Revised content in EPG 616.19- Missouri Quality Standards for TCC Devices to language consistent with current policy and rearranged to flow with the order of first appearance in a work zone. Some revisions included eliminating outdated or unnecessary content, including pictures, for the specific article.

Publications: Engineering Policy Guide: 616.19

## SECTION 610

## PAVEMENT SMOOTHNESS

**610.1 Description.** This work shall consist of measuring the smoothness of the final pavement surface. Smoothness shall be measured using the International Roughness Index (IRI). The following pavement types shall comply with this specification:

(a) Multi-lift asphalt construction greater than 3 inches contained in Secs 401 and 403.

(b) Concrete pavement construction contained in Secs 502 and 506.

(c) Combination of surface planing, such as diamond grinding or milling, and single lift asphalt construction or multi-lift asphalt construction less than or equal to 3 inches contained in Secs 401 and 403.

(d) Single lift asphalt construction contained in Secs 401 and 403.

**610.2 Material Requirements.**

**610.2.1 Inertial Profiler.** IRI shall be computed from profile data collected with an inertial profiler (IP) that meets the requirements of AASHTO M 328

**610.2.2 ProVAL Software.** The ProVAL software program shall be used to compute IRI smoothness and locate areas of localized roughness (ALR) in accordance with MoDOT TM-59.

**610.2.3 Straightedge.** A rolling 10-foot straightedge shall be used for checking longitudinal elevation changes. A 4-foot straightedge shall be used for checking transverse elevation changes.

**610.3 Certification.** All inertial profilers used to collect data on MoDOT projects shall be annually certified at a MoDOT approved ~~the MoDOT~~ certification site in accordance with TM-59. The operator of the IP shall be certified through the MoDOT technician certification program or an approved technician certification program.

-UNCHANGED SPECS- intentionally not shown

**610.5.5 Dispute Resolution.** Any dispute between the engineer and contractor regarding IRI QC/QA comparisons that cannot be settled at the project office level shall be arbitrated ~~with the MoDOT reference profiler per the test procedure in TM-59~~with Third Party resolution in accordance with Sec 403 or Sec 502. The Third Party shall be independent of the contractor, MoDOT consultants and all project subcontractors or suppliers on each specific project. The Third Party shall have properly calibrated and annually certified profiler equipment that meets AASHTO R 56 requirements and the operator has completed profiler certification training through an approved MoDOT Technician Certification Program. The Third Party for smoothness testing shall be listed on the Quality Control Plan in accordance with Sec 403.17.2 or Sec 502.11.1.
~~The results of the reference profiler shall be binding for the engineer and contractor.~~
Whichever of the average QC/QA IRI profiles is closer to the arbitration IRI profile shall be the binding profile for the purpose of construction acceptance.

106.3.2.59 TM-59, Determination of the International Roughness Index

106.3.2.59.1 Equipment

**Inertial Profiler.** The International roughness index (IRI) shall be measured with an inertial profiler (IP). The IP shall meet the equipment requirements of AASHTO M 328, which include the following three primary transducers: (1) a height sensor that measures the distance between the pavement and a vehicle reference point, (2) an accelerometer that measures the vehicle vertical acceleration in response to the pavement profile and (3) a distance sensor that provides a location reference as the vehicle moves longitudinally (see Fig. 106.3.2.59.1). The IP shall also be equipped with an automated triggering system that can automatically start and stop data collection using a reference mark. The IP shall store the profile elevation data at an interval of 2 in. or less and have a vertical measurement resolution of 0.001 in. or less. The IP equipment may be either the low speed or high speed type. The IP shall be capable of exporting unfiltered raw profile data to an electronic file (conforming to ASTM E 2560) that can be imported into the ProVAL software program.

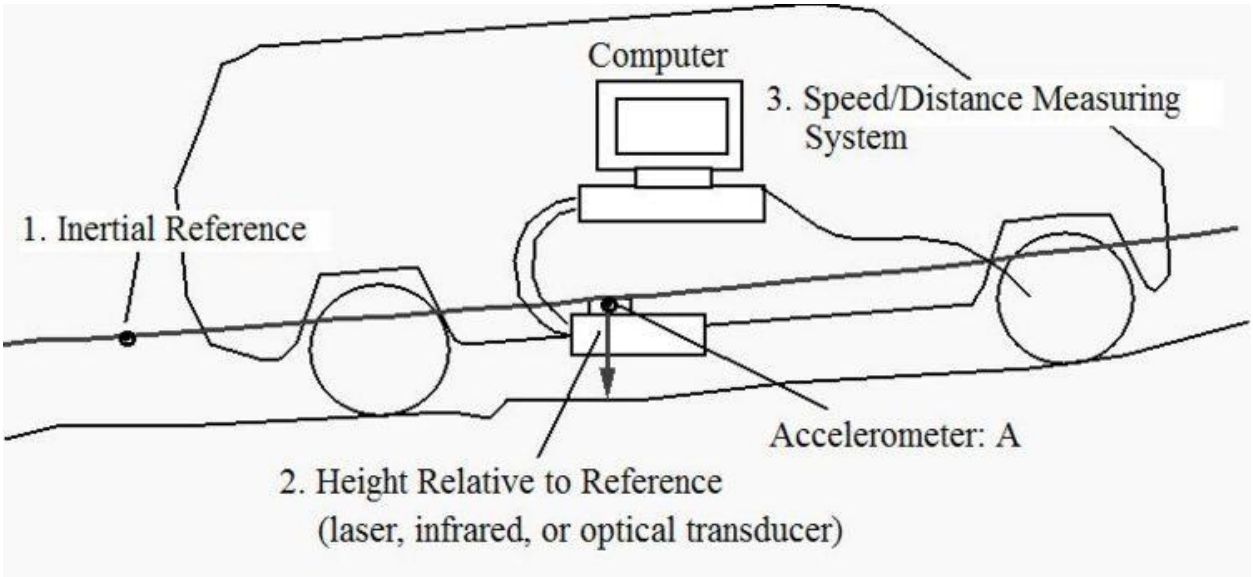



**Fig. 106.3.2.59.1**

**ProVAL.** The profile file shall be evaluated using the ProVAL software program. ProVAL is a free program developed by The Transtec Group under contract with the FHWA. The ~~current~~ newest release of the ProVal program ~~version is~~can be found and downloaded https://www.roadprofile.com. ~~ProVAL 3.4 and can be downloaded.~~

106.3.2.59.2 Inertial Profiler Certification Procedures

Each IP used for construction acceptance testing on a MoDOT project shall be annually certified (verified) at a MoDOT approved certified test site in accordance with AASHTO R 56. ~~the Linn State Technical Colleg test site.~~ The test site will have a known IRI in two wheel paths, measured with a reference profiler.

The inertial profiler (IP) shall have its low- and high-pass filters set to zero prior to the certification test. The IP shall have any other controls set according to manufacturer's specifications. The two sensors in the profiler shall be spaced 6 ft. apart or the distance supplied by the test site facilitator.

The IP operator may perform trial profile runs prior to the certification testing. The IP shall start far enough in advance of the test section to reach data collection speed. The IP operator shall perform five profile runs on the test section collecting data in both wheel paths. The IP shall move at a constant speed over the test section. An IP with two sensors shall measure both wheel path profiles in a single pass. An IP with one sensor shall measure each wheel path profile individually. Upon completion of testing, the IP operator shall provide the certification engineer the unfiltered profiles in .ppf file format on a readable electronic storage device such as a flash drive. Each file shall be labeled in the following format:

Contractor_IP Manufacturer_IP Type_Unique Equipment ID #_Wheel Path Tested_Test Run #.ppf

For "IP Type" enter "HS" for high speed and "LS"' for low speed.

For "Wheel Path Tested" enter "L" for left, "R" for right and "B" for both.

For "Test Run #"' enter 1,2,3,4 or 5.

Ex. CBI_Ames_HS_600406_B_2.ppf.

MoDOT will analyze the submitted data using ProVAL. Based on AASHTO R 56~~-10~~, the test results of the inertial profiler (IP) shall meet the following requirements:

- Minimum average cross-correlation repeatability shall be 92%.
- Minimum average cross-correlation accuracy shall be 90%.

A ProVAL certification report shall be generated for each inertial profiler (IP) that receives acceptable test results at the certification. The report shall be digitally signed with the State Construction and Materials Engineer signature and shall be electronically stored in eProjects and sent to the contractor or testing consultant. Inertial profilers that do not pass the certification test shall be corrected offsite by their respective owners and recertified at a later date.

106.3.2.59.3 Construction Acceptance Procedures

**Testing Conditions.** All objects and foreign material shall be removed from the pavement surface. There shall be no standing water in the wheel paths during testing. Inertial profiler high- and low-pass filters shall be set at zero.

**Testing Limits.** The inertial profiler shall measure the surface of a pavement section in both wheel paths, that are located 3 ft. from and parallel to the edges of the lane, running in the direction of travel.

- The starting point shall be 50 ft. before the start of the day's paving.
- The starting point shall be a known station or ~~logmile~~log mile measured to the nearest foot.
- The IP shall use an automated triggering mechanism to initiate data collection at the starting point and end data collection at the ending point.

- The starting point shall be visibly marked for the duration of the project so that subsequent profile measurements may be closely matched.

**Data Submittal.** The contractor shall submit an electronic file in .ppf format containing the unfiltered raw data collected at the project. Data shall be submitted within 24 hours of testing. The file may consist of more than one section. ~~Inertail~~Inertial profiler files with QC data results shall be submitted to MoDOT using the naming convention in Table 106.3.2.59.3.

**Table 106.3.2.59.3, Categories of Warning Signs and Plaques**

| **Electronic Profilograph File Naming Convention*** | |
|---|---|
| Abbreviation | Definition |
| YYMMDD-###_ | Contract ID (Letting Date-Call Number) |
| YYMMDD_ | Test Date |
| Q_ | Type of quality test (C for control, A for assurance) |
| D | Direction of Lane (N,E,W or S) |
| L | Lane number (1 for inside lane, increasing by one for each lane to the right) |
| W | Wheel path (L, R, or B) |
| S | Beginning Station (rounded to nearest foot) |
| * Example: 100528-501_111103_C_N2R105045.PPF | |

**Data Analysis.** The engineer shall use the ProVAL program to analyze the QC file. ProVAL shall also be used for quality assurance (QA) test data. The analysis will consist of two primary components: 1) *segment smoothness* evaluated with the "Ride Quality" module and 2) *areas of localized roughness* (ALR) evaluated with the "Smoothness Assurance" module.

**EPG 106.3.2.59.3.1 and 106.3.2.59.3.2 intentionally not shown due to no changes**

106.3.2.59.4 Dispute Resolution

~~MoDOT Reference Profiler~~

In the event that the QC/QA results are not within tolerance (after the absolute value of the difference between the contractor and engineer IRIs are computed for each segment within the QA test length, the average of the absolute values of the IRI difference shall be 8 in./mile or less and the absolute value of the IRI difference for any single segment shall be 12 in./mile or less), ~~the MoDOT SurPro reference profiler shall arbitrate the dispute~~dispute resolution involving Third Party shall be conducted in accordance with Sec 403 or Sec 502. The Third Party shall test the entire disputed length with a calibrated and certified profiler.~~engineer shall randomly select a 528 ft. area within the disputed pavement length and run the MoDOT reference profiler in the left and right wheel paths.~~ The arbitration profile shall be correlated with its corresponding QC and QA profiles in ProVAL. Whichever of the average QC/QA IRI profiles is closer to the arbitration IRI profile shall be the binding profile for the purpose of construction acceptance.

## SECTION 606

## GUARDRAIL, CRASHWORTHY END TERMINALS, ONE-STRAND ACCESS RESTRAINT CABLE AND ~~THREE-STRAND~~ GUARD CABLE

**606.1 Description.** This work shall consist of furnishing and installing guardrail, crashworthy end terminals, one-strand access restraint cable or ~~three-strand~~ guard cable which includes low-tension and high-tension as shown on the plans or as directed by the engineer.

**606.2 Material.** All material shall be in accordance with Division 1000, Material Details, and specifically as follows:

| Item | Section |
|---|---|
| Concrete | 501 |
| Guardrail, End Terminals, Crash Cushions, One-Strand Access Restraint Cable and ~~Three-Strand~~ Guard Cable | 1040 |

**606.2.1 Concrete.** Concrete shall be placed, finished and cured in accordance with Sec 703.

**606.2.2 Cold Weather.** During cold weather, the weather limitations of Sec 502 will apply to concrete work.

**606.2.3 Aesthetic Guardrail.** When specified, aesthetic guardrail shall be in accordance with ~~NCHRP 350,~~MASH 2016, Test Level 3 criteria and shall be of new stock. End terminals and crash cushions for aesthetic guardrail shall be fabricated and installed in accordance with Sec 606.30.3.

**606.3 Construction Requirements.**

**606.3.1 General.** Work on guardrail or guard cable removal and replacement when the adjacent travel or auxiliary lane is open to traffic during non-working hours shall adhere to the following requirements:

(a) The contractor shall provide a schedule of work prior to the beginning of work.

(b) Remove no more guardrail or guard cable than can be replaced in the same day.

(c) Schedule guardrail and guard cable installation to ensure guardrail beam or guard cable is properly attached to all installed posts at the end of each work day.

(d) Ensure end sections or terminals exposed to traffic meet current standards.

(e) Notify the engineer prior to delivery of the material to the project.

**606.3.1.1** If guardrail or ~~three-strand~~ guard cable cannot be replaced the same day as removal, traffic control measures meeting the approval of the engineer shall be provided. The contractor will not be compensated for any additional traffic control items required to perform this work. In all cases, the contractor shall ensure that the guardrail or guard cable installation is fully anchored before opening the adjacent lane to traffic.

UNCHANGED SPECS- INTENTIONALLY NOT SHOWN

## SECTION 606.50 ~~THREE-STRAND~~ GUARD CABLE.

**606.50.1 Description.** This work shall consist of furnishing and installing ~~three-strand~~ guard cable which may include low-tension or high-tension, including all hardware, appurtenances and aggregate bedding, as shown on the plans or as directed by the engineer.

**606.50.2 Construction Requirements.** Low-tension guard cable shall not be used for new barrier installations. Existing low-tension guard cable may remain in place as long as the guard cable system is in serviceable condition. Existing low-

tension guard cable systems may be repaired when damaged if practical. If not practical, low-tension guard cable should be replaced with high-tension guard cable. High-tension guard cable systems shall be fabricated and installed in accordance with the manufacturer's approved shop drawings, recommendations and as shown on the plans. Any units damaged during the term of the contract shall be replaced immediately at the contractor's expense.

**606.50.2.1 Line Posts.** All posts shall be driven unless otherwise directed by the engineer. Driving shall be accomplished with approved equipment and methods that will leave the posts in the final position, free from any distortion, burring or other damage. All posts shall be aligned to a tolerance of 1/4 inch for plumb and grade line. If rock is encountered when setting line posts, the contractor may set line posts with or without a soil plate. Line posts set with a soil plate shall be installed by digging or boring a hole into the rock to the required depth and of sufficient size for the post to be set with the soil plate attached. Line posts set without the soil plate shall be installed by drilling a hole to the required depth not to exceed 5 inches in diameter. Following placement of the post, the hole shall be backfilled with a cohesive soil or sand in accordance with Sec 1005.3, and thoroughly tamped.

**606.50.2.2 Anchor Assemblies.** The specified type of anchor assembly shall be constructed at each end of a run of guard cable. If intermediate end anchors are required, the cable assembly shall be overlapped as shown on the plans. The location of all intermediate anchor assemblies shall be determined by the contractor and approved by the engineer. The concrete anchor shall be cast in place with the centerline normal to the line of the guard cable. The top 12 inches of the anchor below finished ground line shall be formed, unless the engineer determines soil conditions permit excavation to be made to the neat lines of the anchor and the anchor cast against the undisturbed vertical soil face. Anchors shall be constructed on firm, stable, undisturbed soil to the minimum dimensions shown on the plans. Anchor bolts and anchor post slip bases shall be firmly held in the proper position supported at the top by a template during concrete placement. Backfill shall be thoroughly compacted with mechanical tampers with care taken to prevent damage to the finished concrete. Backfill shall be brought up level with the finished grade line. The anchor may be cast in place or precast as either one or two units.

**606.50.2.3 Cables.** Cables shall be attached to the line posts, anchor posts, cable transition brackets and anchor brackets as shown on the plans. Where compensating devices or turnbuckles are required, the cables shall be attached to the end anchor with turnbuckles fully opened. Compensating devices and turnbuckles shall be installed such that no interference with the functions of any other part of the system occurs. Individual cables may be spliced with a device approved by the engineer. Each cable shall be stretched taught by mechanical means to eliminate sag between the posts. The contractor may tighten cable hook bolts after final cable tensioning is complete to allow cable slack to be adequately taken up. Prior to final acceptance, the cables shall be tensioned in accordance with the temperature and spring compression table shown on the plans and all cable hook bolts tightened. Repair splices for low-tension systems will be no closer than 400 feet and no more than 4 splices per cable within a 2000 foot run. When a repair to a low-tension cable requires splices closer than 400 feet or more than 4 splices per cable within a 2000 foot run, the full 2000 feet cable length may be replaced with the engineer's approval. Repair splices for high-tension systems will be no closer than 200 feet per cable within a 1000 foot run. When a repair to a high-tension cable requires splices closer than 200 feet, a longer section may be replaced to reduce the number of splices from turnbuckle to turnbuckle with the engineer's approval.

**606.50.2.4 Aggregate Bedding.** Material for aggregate bedding shall consist of a durable crushed stone, shot rock or broken concrete with approximately 20 percent of the pieces being between 1 inch and 3 inches in diameter but none greater than 3 inches. The remainder of the material shall be such that provides a uniform, angular appearance. Acceptance by the engineer will be made by visual inspection.

**606.50.2.5 Delineators.** Delineator spacing and reflector colors shall be in accordance with Sec 606.10.

**606.50.3 Method of Measurement.**

**606.50.3.1 ~~Three-Strand~~ Guard Cable.** Measurement of ~~three-strand~~ guard cable will be made from center of line post to center of line post, totaled to the nearest linear foot.

**606.50.3.2 Anchor Assemblies.** Measurement of anchor assemblies will be made per each.

**606.50.3.3 Aggregate Bedding.** Aggregate bedding material will be measured to the nearest cubic yard of material.

**606.50.4 Basis of Payment.** The accepted quantities of ~~three-strand~~ guard cable, end anchors, posts, hardware and aggregate bedding will be paid for at the contract unit price for each of the pay items included in the contract. No direct payment will be made for setting posts in rock. No direct payment will be made for guard cable delineators provided on new guard cable. Delineators specified for installation on existing guard cable will be measured and paid for per each.

## SECTION 1040

## GUARDRAIL, END TERMINALS, ONE-STRAND ACCESS RESTRAINT CABLE AND ~~THREE-STRAND~~ GUARD CABLE MATERIAL

**1040.1 Scope.** This specification covers guardrail, end terminals, one-strand access restraint cable, ~~three-strand~~ guard cable which includes low-tension and high-tension, and all appurtenances required for installation.

UNCHANGED SPECS- INTENTIONALLY NOT SHOWN

**1040.5.2 Manufacturer's Approval.** Prior to approval and use of an end terminal, the ~~manufacturer~~ contractor shall submit to MoDOT the manufacturer's name, the product brand name or model number, a copy of the MASH 2016 test results, a copy of the FHWA eligibility letter, and shop drawings.

UNCHANGED SPECS- INTENTIONALLY NOT SHOWN

**1040.7.2 ~~Three-Strand~~ Guard Cable.**

**1040.7.2.1 Cable and Connecting Hardware.** The cable and connecting hardware shall be in accordance with AASHTO M 30 and AASHTO M 269. The wire rope shall be Type 1, 3/4-inch diameter, 3 by 7 construction with a Class A coating. The rope, with connecting hardware, shall develop the breaking strength at a minimum of ~~a~~ 25,000-pound single cable. Connecting hardware shall be galvanized in accordance with AASHTO M 232 or may be mechanically galvanized. If mechanically galvanized, the coating, thickness, adherence and quality requirements shall be in accordance with AASHTO M 232, Class C. Cast Steel components shall be in accordance with AASHTO M 103, Grade 70-40, Class 1. Malleable iron castings shall be in accordance with ASTM A47. Compensating devices shall have a spring constant of 0.46 psi, plus or minus 0.06 pound per inch, and permit 6 inches of travel, plus or minus one inch. All threaded parts on compensating cable end assemblies shall be in accordance with ASTM F568, Class 4.6, 3/4-10 threads. Socket baskets shall be designed for use with the cable anchor wedge as shown on the plans. Guard cable anchor brackets shall be manufactured from an AASHTO M 270, Grade 250 steel plate, and zinc-coated in accordance with AASHTO M 111. Dimensional tolerances not shown on the plans shall be consistent with the proper functioning of the part, including the part's appearance and accepted manufacturing process.

**1040.7.2.2 Cable Brackets.** Steel used in the fabrication of the bracket shall be in accordance with ASTM A36. The bracket shall be galvanized after fabrication in accordance with AASHTO M 111. All fittings, including splices, shall be designed to use the wedge detail, and shall be of such section as to develop the full strength of the 3/4-inch, at a minimum of 25,000-pound round cable. Designs for a combination or single-unit compensating device and turnbuckle assembly shall be submitted for approval. Compensating devices shall have a spring rate of 0.46 ± 0.03 pound per inch, and shall permit 6 inches ± one inch of travel. All parts, except cable wedge, shall be hot-dip zinc coated in accordance with AASHTO M 232 or AASHTO M 298.

**1040.7.2.3 Hook Bolts, Hex Bolts, Nuts and Washers.** Hook bolts, hex bolts and washers shall be in accordance with ASTM A307. Cable hook nuts shall be 5/16-18 threads and in accordance with ASTM A563. Hook bolts, as installed, shall develop an ultimate pull open strength of 450 to 1,000 pounds applied in a direction normal to the axis of the post. Hooked anchor studs shall be in accordance with AASHTO M 314, except the threads and nominal diameter shall be 3/4-10 and in accordance with ASTM F568, Class 4.6. All items shall be galvanized in accordance with AASHTO M 232 or may be mechanically galvanized in accordance with AASHTO M 232, Class C.

**1040.8 Certification.** The contractor shall furnish the manufacturer's certification for all material governed by this specification. Specifically, each certification shall indicate compliance with the requirements of each applicable section and as set forth in Table I.

**1040.8.1 Manufacturer's Approval.** Prior to a new installation of an approved high-tension guard cable system, the contractor shall submit to MoDOT the manufacturer's name, the product brand name or model number, a copy of the MASH 2016 test results, a copy of the FHWA eligibility letter, and shop drawings.

**1040.9 Repair of Galvanizing.** Galvanized material shall be handled in a manner to avoid damage to the surface. No field punching, drilling, cutting or welding will be permitted after galvanizing. Any galvanized material on which the

spelter coating has been damaged will be rejected or may be repaired in accordance with Sec 1081, with approval from the engineer.

**TABLE I - Certification Requirements**

| Item | Galvanizing Standard | Steel Grade | Other |
|---|---|---|---|
| Wood Post and Blocks | - | - | a |
| Steel Posts, Plates and Brackets | AASHTO M 111 | AASHTO M 270, Grade 36 | b |
| Plastic Blocks | - | - | g |
| Guardrail Beam | Sec 1040.4 | Sec 1040.4 | b, c |
| Bolts, Nuts and Washers | AASHTO M 232 | ASTM A307 | |
| End Terminals Systems | - | - | f |
| End Anchors<br>- Tubes<br>- Transition Cap Rail | <br>AASHTO M 111<br>AASHTO M 111 | <br>ASTM A500/ASTM A501<br>AASHTO M 270, Grade 36 | <br>b<br>b |
| One-Strand Access Restraint Cable<br>- Cable<br>- Hardware | <br>AASHTO M 30<br>AASHTO M 232 | <br>AASHTO M 30<br>AASHTO M 102/ ASTM A220 | <br>b<br>b |
| ~~Three Strand~~ Guard Cable<br>- Cable<br><br>- Hardware<br><br>- Cast Steel Components<br>- Malleable Iron Castings<br>- Anchor Brackets<br>- Cable Brackets<br>- Hook and Hex Bolts<br>- Hook Nuts<br>- Hooked Anchor Studs | <br>AASHTO M30<br><br>AASHTO M 232<br><br>AASHTO M 232<br>AASHTO M 232<br>AASHTO M 111<br>AASHTO M 111<br>AASHTO M 232<br>AASHTO M 232<br>AASHTO M 232 | <br>AASHTO M 30 & AASHTO M 269<br>AASHTO M 102/ ASTM A220<br>AASHTO M 103<br>ASTM A47<br>AASHTO M 270<br>AASHTO M 270, Grade 36<br>ASTM A307<br>ASTM A563<br>AASHTO M 314 | b<br>d<br>d<br>d<br>e<br>d |

(a) Certification shall state that the material is in accordance with Sec 1050 and shall include a listing of the material supplied and a certified test report as detailed in Section 7.2 of AWPA, Standard M2, attesting to complete compliance with this specification.

(b) Certification shall include, or have attached, specific results of laboratory tests for physical and chemical properties from samples representative of the material.

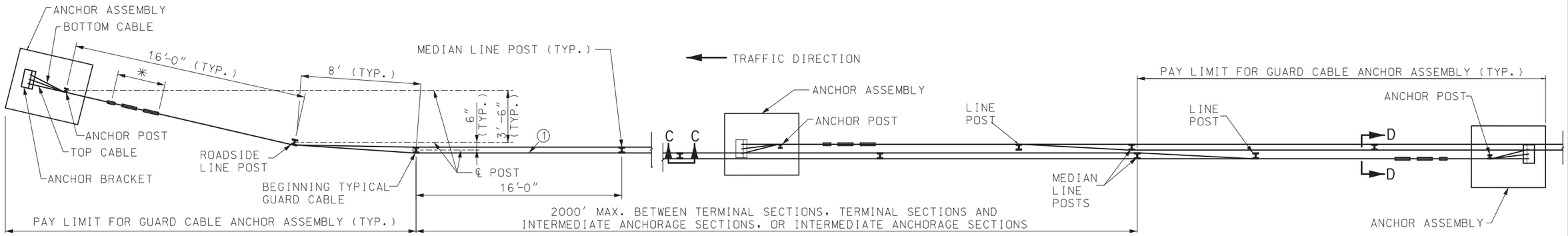
(c) Shall have Brand Registration and Guarantee on file, including certification indicating the coating is either Type 1 by Continuous Galvanizing Method or Type 2.

(d) All threaded parts of compensating cable end assemblies and hooked anchor studs shall be in accordance with ASTM F568.

(e) All fittings for cable bracket, except the cable wedge, shall be in accordance with AASHTO M 232 or AASHTO M 298.

(f) Certification shall state the name of the manufacturer and that the units furnished are identical in material and design as those tested for performance in accordance with Sec 606.30.

(g) Certification shall state that the materials furnished are identical in chemistry, mechanical properties and geometry as those that passed the NCHRP 350 or MASH-2016 crash test, and as those that were approved by the Missouri Department of Transportation.

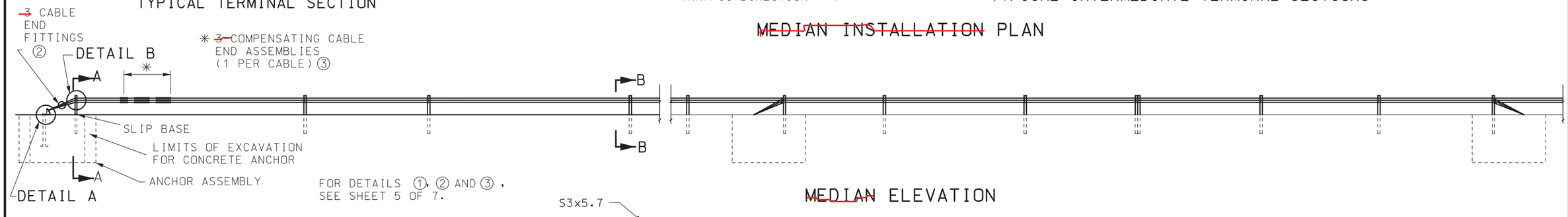



TYPICAL TERMINAL SECTION

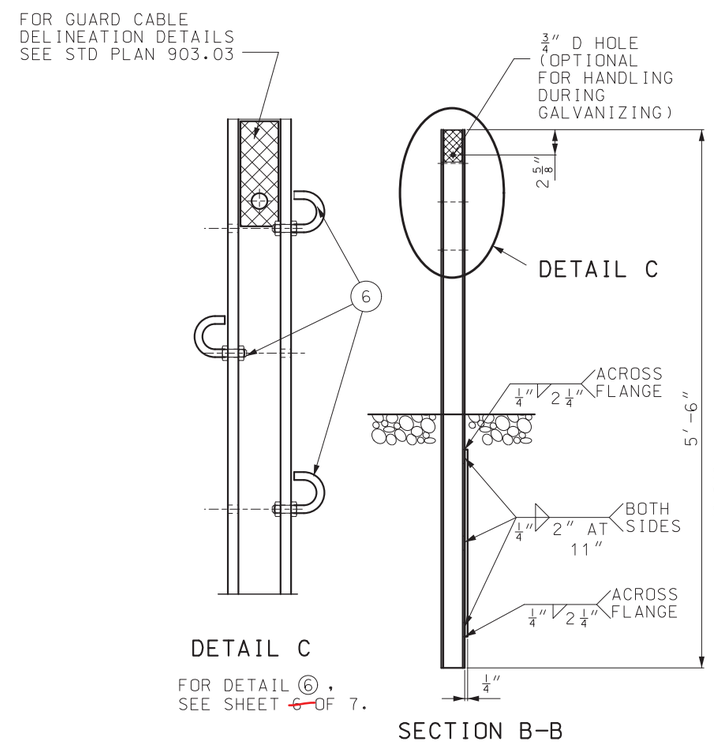
TYPICAL INTERMEDIATE TERMINAL SECTIONS

TRAFFIC DIRECTION →

~~MEDIAN INSTALLATION~~ PLAN

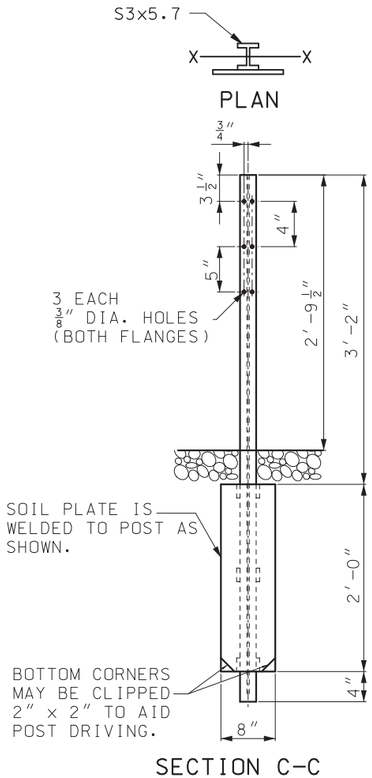


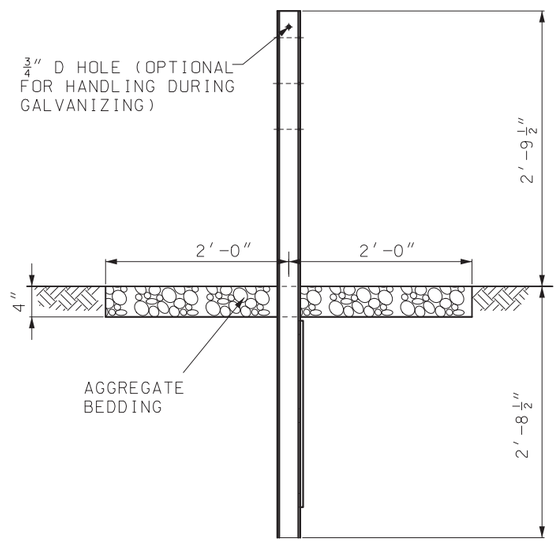

~~MEDIAN~~ ELEVATION










GENERAL NOTES:

IN THE EVENT THE NORMAL 16' POST SPACING WOULD PLACE A POST ON A DROP INLET, THE SPACING OF THE TWO POSTS IMMEDIATELY PRECEDING THE INLET SHALL BE REDUCED SUCH THAT THE FOLLOWING POST CLEARS THE INLET. EACH SUBSEQUENT POST SHALL BE SPACED AT 16'. IN NO CASE SHALL THE SPACING EXCEED 16'.

IN THE EVENT A LONGITUDINAL MEDIAN PIPE IS ENCOUNTERED THE CABLE SHALL BE PLACED PARALLEL TO THE PIPE AT A MINIMUM OFFSET OF 12". THE OFFSET SHALL BE ACHIEVED BY A MINIMUM 16:1 TAPER ON THE UPSTREAM AND DOWNSTREAM END OF THE PIPE.

FOR SECTION A-A▼AND DETAIL B, SEE SHEET ~~5~~ Detail A 5 OF ~~7~~.

FOR GUARD CABLE DELINEATION DETAILS SEE STD PLAN 903.03.



MISSOURI HIGHWAYS AND TRANSPORTATION COMMISSION
105 WEST CAPITOL
JEFFERSON CITY, MO 65102
1-888-ASK-MODOT (1-888-275-6636)

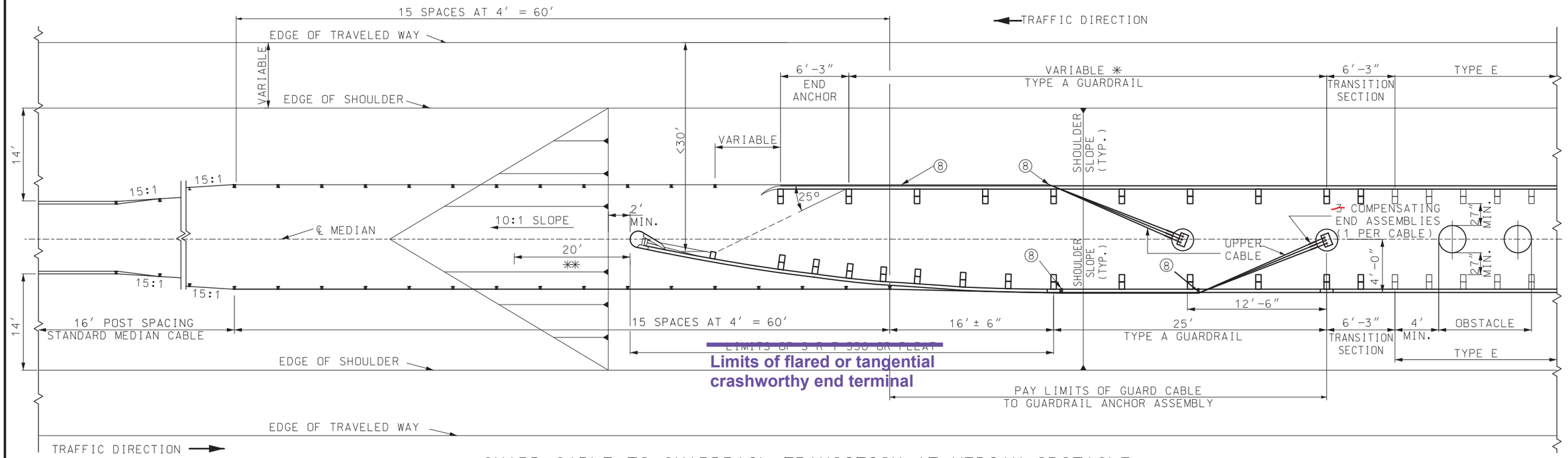
STATE OF MISSOURI
TRAVIS D. KOESTNER
NUMBER PE-30042
PROFESSIONAL ENGINEER
THIS SHEET HAS BEEN SIGNED, SEALED AND DATED ELECTRONICALLY.

# REPAIR ONLY LOW-TENSION ~~THREE-STRAND~~ GUARD CABLE ~~MEDIAN APPLICATION~~

DATE EFFECTIVE: 04/01/2021
DATE PREPARED: 1/27/2021

606.41M

SHEET NO. 1 OF 7

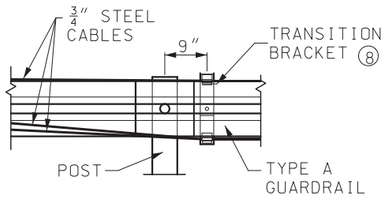



## GUARD CABLE TO GUARDRAIL TRANSITION AT MEDIAN OBSTACLE

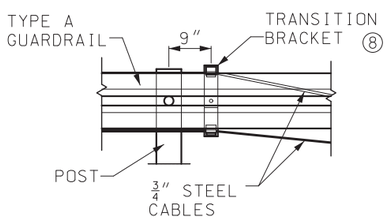
✳ VARY LENGTH TO ACHIEVE 25° DEFLECTION TO SECOND POST OF ~~S-R-T 350 OR FLEAT~~ flared or tangential crashworthy end terminal.

✳✳ IF GUARD CABLE IS USED WITH BULLNOSE GUARDRAIL SYSTEM, OR A CRASHWORTHY END TERMINAL ON A MEDIAN LESS THAN 60′ IN WIDTH, THE CABLE ANCHORAGE SHALL BE PLACED ON THE MEDIAN CENTERLINE 20′ FROM THE NOSE OF THE CRASHWORTHY END TERMINAL OR BULLNOSE GUARDRAIL SYSTEM.

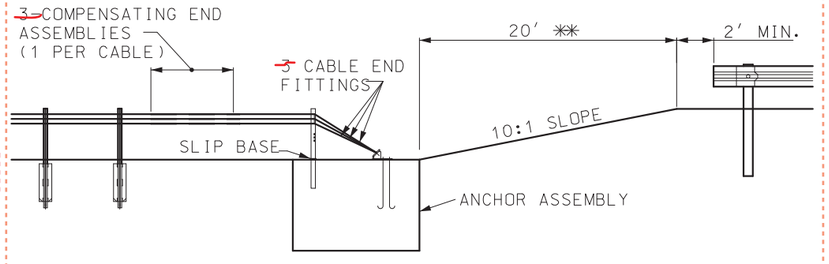
MOVE TO SHEET 4




DETAIL C

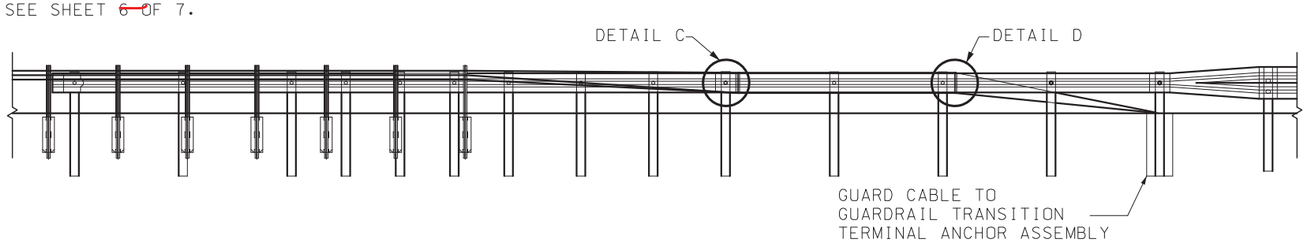



DETAIL D




PROFILE OF TRANSITION AT MEDIAN OBSTACLE WITH BULLNOSE OR IN A MEDIAN NARROWER THAN 60′

FOR DETAIL ⑧ SEE SHEET ~~6~~ OF 7.




TYPICAL GUARD CABLE TO GUARDRAIL TRANSITION ELEVATION

GENERAL NOTES:

WHEN GUARD CABLE IS LOCATED ALONG THE MEDIAN CENTERLINE NEAR A BRIDGE END OR CONCRETE BARRIER, IT SHALL BE ANCHORED BEHIND THE GUARDRAIL ASSEMBLY WITH THE GUARD CABLE ANCHOR ASSEMBLY. THE GUARD CABLE ANCHOR SHALL BE ~~CONSTRUCTED SO THAT IT IS~~ PROTECTED BY THE GUARDRAIL.

THIS DRAWING DEPICTS ~~OPTIONS FOR~~ THE ATTACHMENT OF GUARD CABLE TO GUARDRAIL. IT DOES NOT INDICATE THAT TWO RUNS OF CABLE ARE REQUIRED.

SUITABLE DRAINAGE MUST BE PROVIDED WHEN MEDIAN GRADING IMPEDES NORMAL FLOW.

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REPAIR ONLY LOW-TENSION ~~THREE-STRAND~~ GUARD CABLE

DATE EFFECTIVE: 04/01/2021
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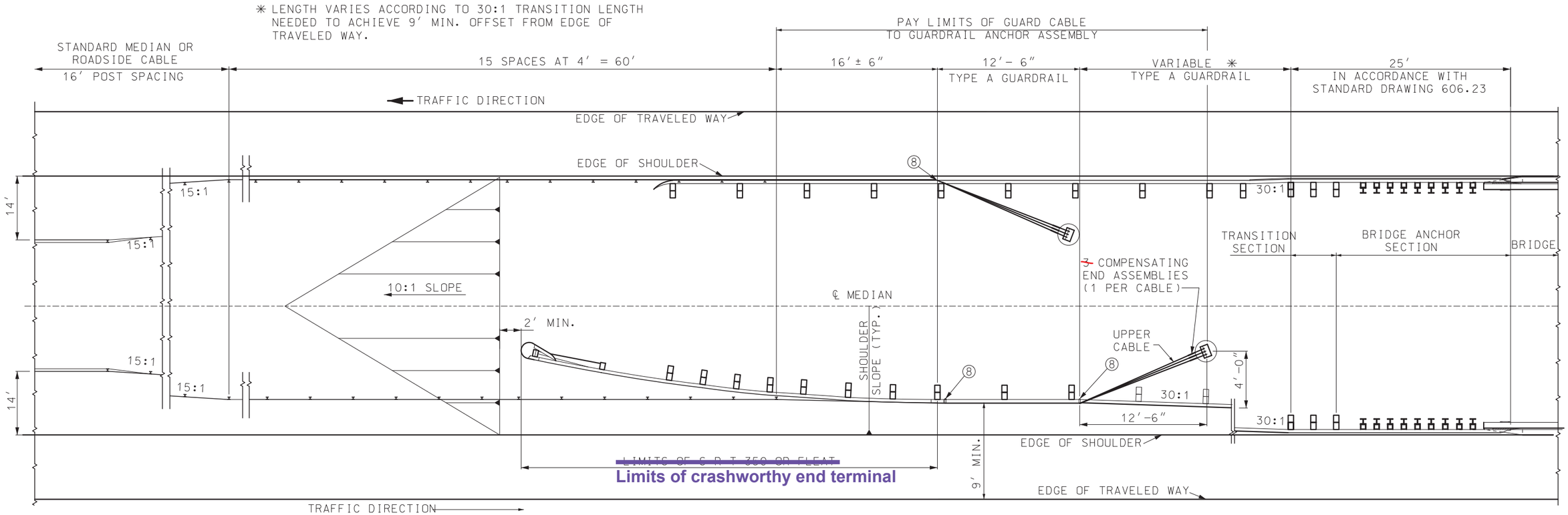
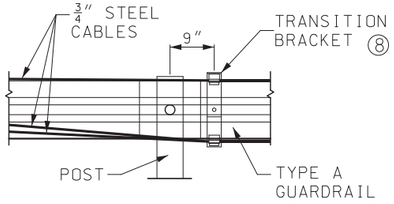
606.41M

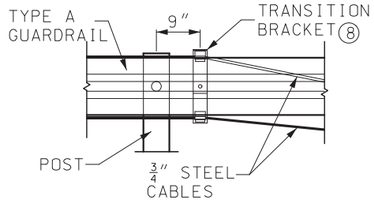
SHEET NO. 2 OF 7




## GUARD CABLE TO GUARDRAIL TRANSITION AT MEDIAN BRIDGE END

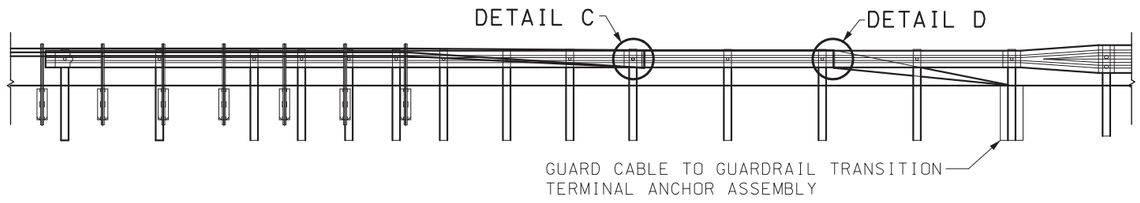



DETAIL C




DETAIL D

FOR DETAIL ⑧
SEE SHEET ~~6 OF~~ 7.




TYPICAL GUARD CABLE TO GUARDRAIL TRANSITION ELEVATION

GENERAL NOTES:

WHEN GUARD CABLE IS LOCATED ALONG THE MEDIAN CENTER-LINE NEAR A BRIDGE END OR CONCRETE BARRIER, IT SHALL BE ANCHORED BEHIND THE GUARDRAIL ASSEMBLY WITH THE GUARD CABLE ANCHOR ASSEMBLY. THE GUARD CABLE ANCHOR SHALL BE ~~CONSTRUCTED SO THAT IT IS~~ PROTECTED BY THE GUARDRAIL.

THIS DRAWING DEPICTS ~~OPTIONS FOR~~ THE ATTACHMENT OF GUARD CABLE TO GUARDRAIL. IT DOES NOT INDICATE THAT TWO RUNS OF CABLE ARE REQUIRED.

SUITABLE DRAINAGE MUST BE PROVIDED WHEN MEDIAN GRADING IMPEDES NORMAL FLOW.

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REPAIR ONLY LOW-TENSION

~~THREE-STRAND~~
GUARD CABLE

DATE EFFECTIVE: 04/01/2021
DATE PREPARED: 1/27/2021

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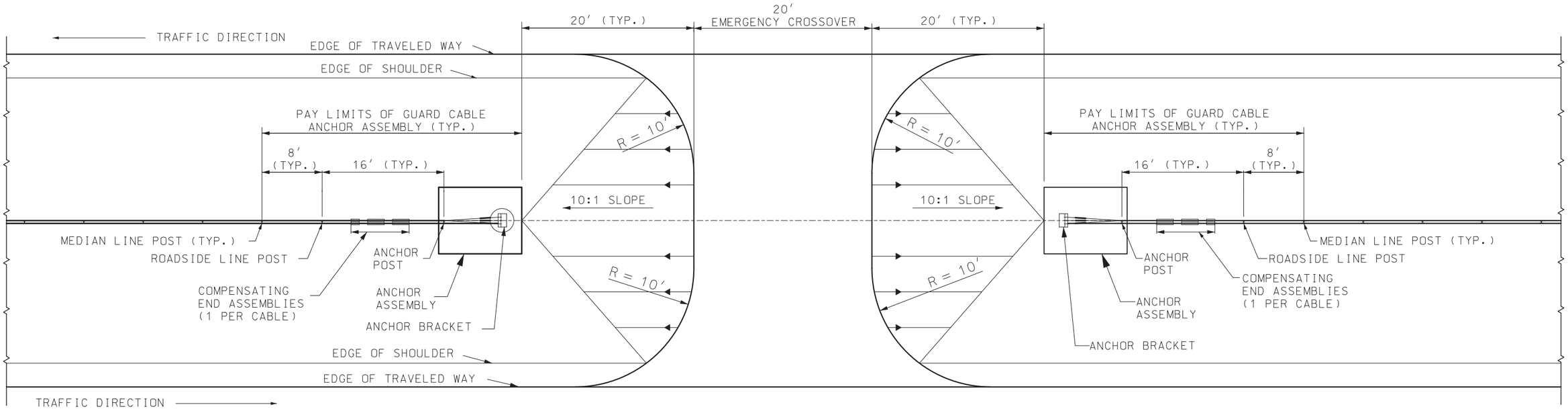
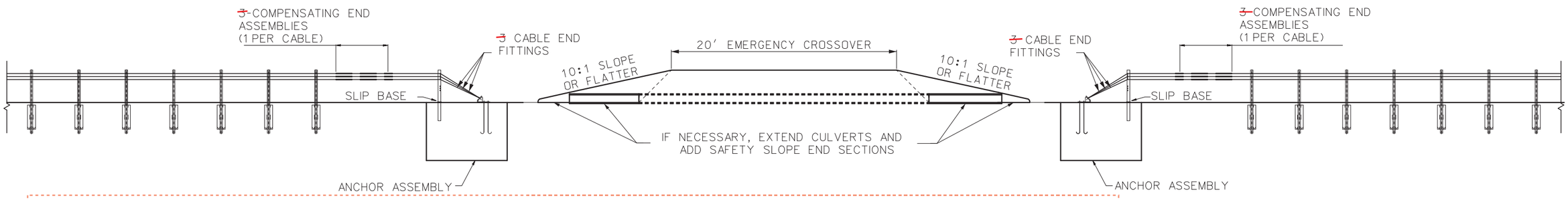
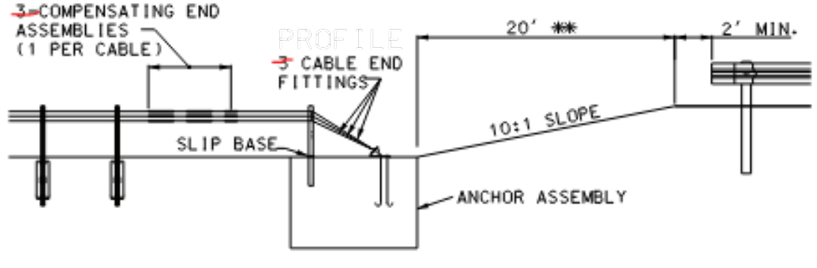
SHEET NO.
3 OF 7




PLAN




MOVED FROM SHEET 2




** IF GUARD CABLE IS USED WITH BULLNOSE GUARDRAIL SYSTEM, OR A CRASHWORTHY END TERMINAL ON A MEDIAN LESS THAN 60′ IN WIDTH, THE CABLE ANCHORAGE SHALL BE PLACED ON THE MEDIAN CENTERLINE 20′ FROM THE NOSE OF THE CRASHWORTHY END TERMINAL OR BULLNOSE GUARDRAIL SYSTEM.

PROFILE OF TRANSITION
AT MEDIAN OBSTACLE WITH BULLNOSE
OR IN A MEDIAN NARROWER THAN 60′

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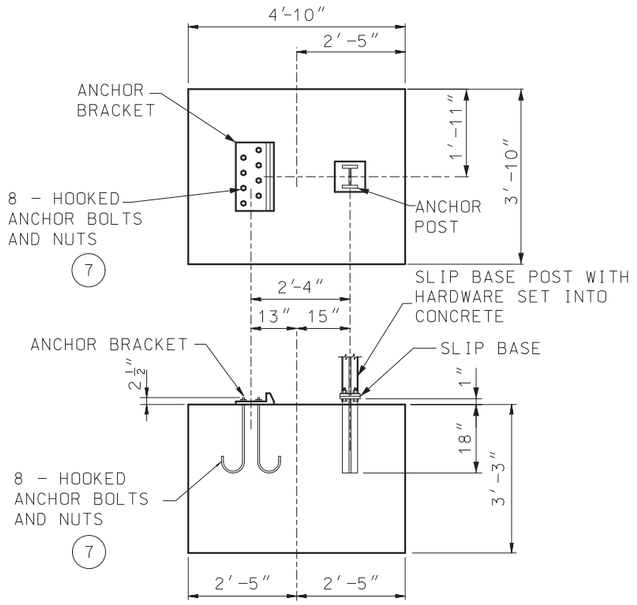
REPAIR ONLY LOW-TENSION
~~THREE-STRAND~~
GUARD CABLE
TRANSITION AT MEDIAN OPENING

DATE EFFECTIVE: 04/01/2021
DATE PREPARED: 1/27/2021

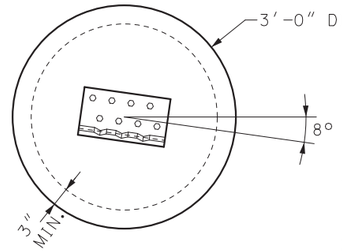
606.41M

SHEET NO.
~~4~~ 7 OF 7

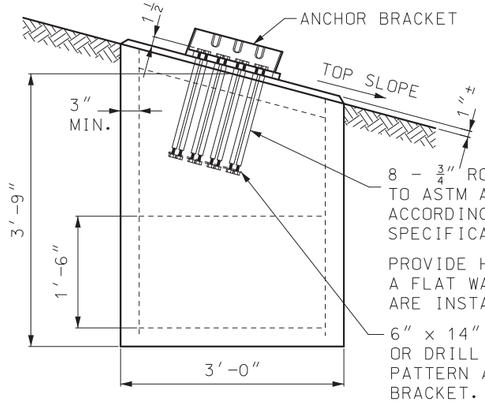



## MEDIAN AND ROADSIDE CABLE

NOTES:
1. PLACE ANCHORS SO THE TOPS ARE LEVEL; WARP SLOPE TO FIT.
2. THE CONCRETE ANCHOR BLOCK DOES NOT REQUIRE REINFORCEMENT.




NOTES:
1. REINFORCEMENT CONSISTS OF NO. 3 BARS PLACED AS SHOWN.
2. TOP SLOPE TO MATCH ADJACENT CROSS SLOPE.




8 - ¾" ROUND x 18" LONG STEEL RODS CONFORMING TO ASTM A449 WITH THE TOP 6" OF THE RODS GALVANIZED ACCORDING TO SECTION 1080 OF THE MISSOURI STANDARD SPECIFICATIONS FOR HIGHWAY CONSTRUCTION.

PROVIDE HEAVY HEX NUTS AT EACH END OF EACH ROD PLUS A FLAT WASHER AT THE TOP END. AFTER THE TOP NUTS ARE INSTALLED, PUNCH THE THREADS TO PREVENT ROTATION.

6" x 14" x ¼" PLATE - PUNCH OR DRILL TO THE SAME PLAN PATTERN AS THE CABLE ANCHOR BRACKET.

## GUARD CABLE TO GUARDRAIL TRANSITION

| STANDARDIZED HARDWARE | |
|---|---|
| 1 | WIRE ROPE |
| 2 | CABLE END FITTING |
| 3 | COMPENSATING CABLE END ASSEMBLY |
| 4 | ANCHOR BRACKET |
| 5 | U-BOLT CABLE CLIPS |
| 6 | CABLE HOOK BOLT AND NUT |
| 7 | HOOKED ANCHOR BOLT AND NUTS |
| 8 | CABLE TRANSITION BRACKET |

GENERAL NOTES:

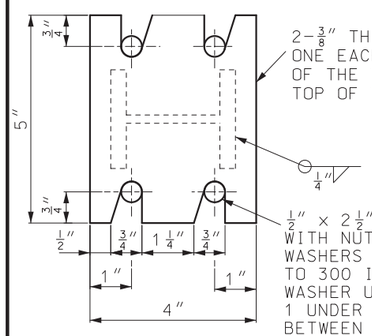
FOR ARRANGEMENT OF SPRING AND COMPENSATING CABLE END ASSEMBLIES AND TURNBUCKLE CABLE END ASSEMBLIES, THE FOLLOWING CRITERIA SHALL APPLY: LENGTH OF CABLE RUNS TO 1000' - USE COMPENSATING CABLE END ASSEMBLY ON ONE END AND THE TURNBUCKLE CABLE END ASSEMBLY ON THE OTHER END OF EACH INDIVIDUAL CABLE. FOR LENGTHS LONGER THAN 1000' AND UP TO AND INCLUDING 2000' - USE COMPENSATING CABLE END ASSEMBLY ON EACH END OF THE INDIVIDUAL CABLE.

PRIOR TO FINAL ACCEPTANCE BY THE ENGINEER, THE FOLLOWING PROCEDURES SHALL BE USED TO TIGHTEN THE TURNBUCKLES. DEPENDING ON THE TEMPERATURE AT THE TIME OF THE ADJUSTMENT IN ACCORDANCE WITH THE FOLLOWING TABLE:

| TEMPERATURE (°F) | SPRING COMPRESSION FROM UNLOADED POSITION IN EACH SPRING |
|---|---|
| 120 TO 100 | 1" |
| 99 TO 80 | 1½" |
| 79 TO 60 | 2" |
| 59 TO 40 | 2½" |
| 39 TO 20 | 3" |
| 19 TO 0 | 3½" |
| -1 TO -20 | 4" |

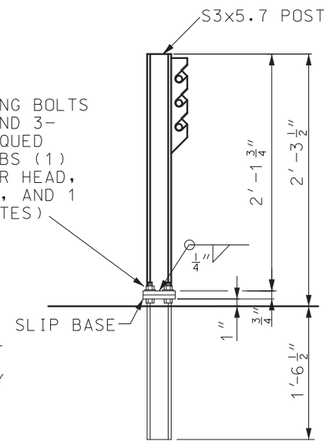
THE SPECIFICATIONS AND DIMENSIONS OF ALL HARDWARE AND FITTINGS SHALL COMPLY WITH AASHTO-AGC-ARTBA JOINT COMMITTEE TASK FORCE 13 REPORT, A GUIDE TO STANDARDIZED HIGHWAY BARRIER HARDWARE.

## TERMINAL ANCHOR ASSEMBLY

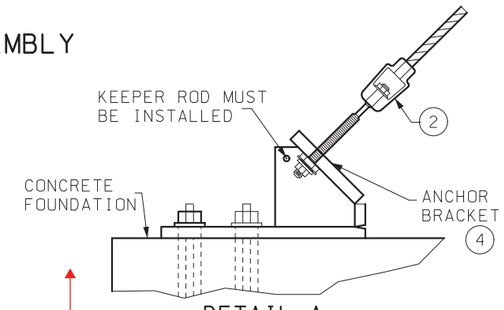



SLIP BASE PLATE

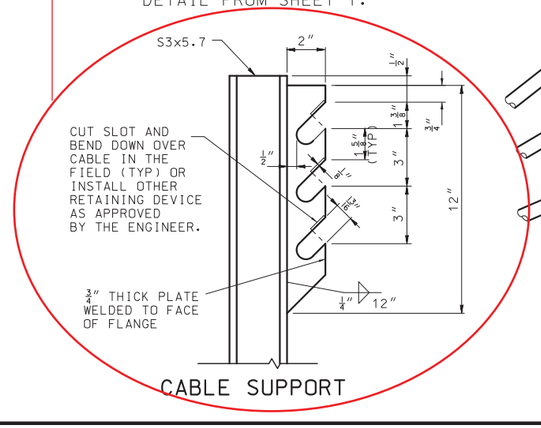
NOTES:
1. LINE POST CABLE SPACING SHALL BE TRANSITIONED TO 3" BETWEEN THE TWO LINE POSTS IMMEDIATELY PRECEDING THE ANCHOR POST.
2. CABLES PLACED ON BOTH POST FACES SHALL BE TRANSITIONED TO THE FRONT FACE BETWEEN THE TWO LINE POSTS IMMEDIATELY PRECEDING THE ANCHOR POST.




SECTION A-A
ANCHOR POST



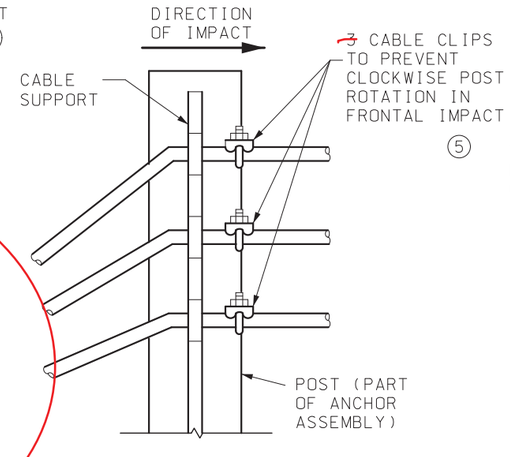

DETAIL A
ANCHOR BRACKET
DETAIL FROM SHEET 1.




CABLE SUPPORT

FOR DETAILS ② AND ④, SEE SHEET ~~5~~ 6 OF ~~7~~.

FOR DETAIL ⑤ AND ⑦, SEE SHEET ~~6~~ OF 7.




DETAIL B
CABLE CLIPS
DETAIL FROM SHEET 1.



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# REPAIR ONLY LOW-TENSION ~~THREE-STRAND~~ GUARD CABLE

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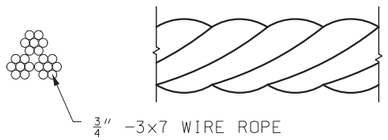
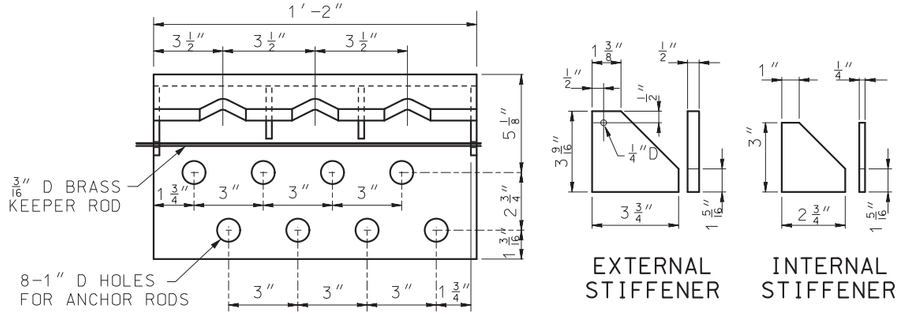
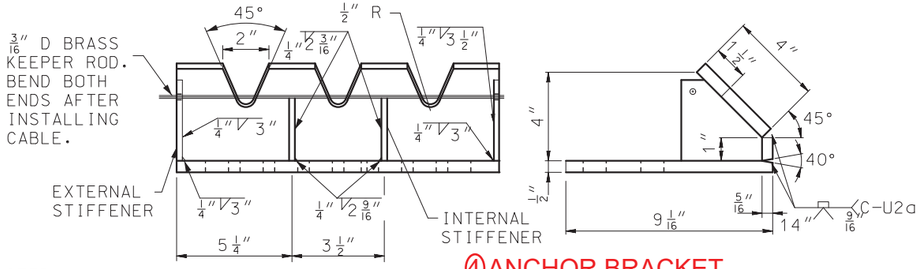
SHEET NO.
5~~4~~ OF 7




① WIRE ROPE

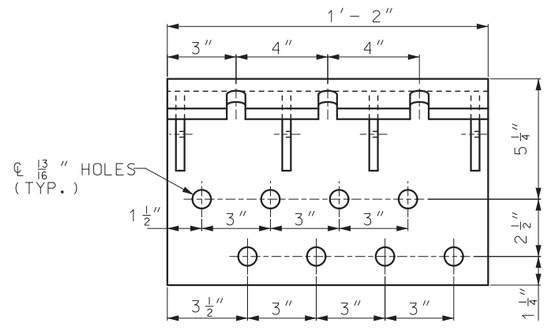


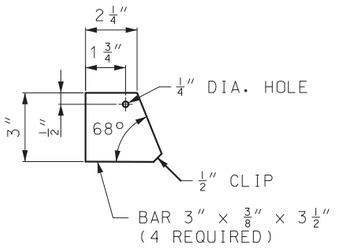




④ANCHOR BRACKET

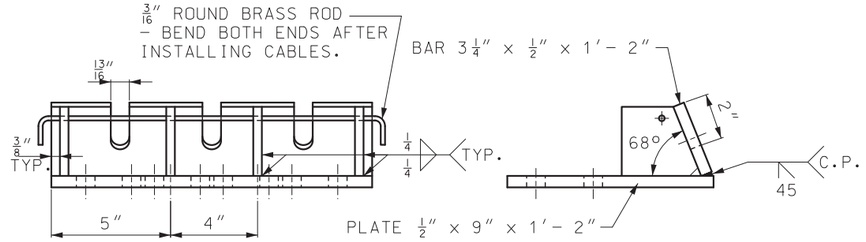
~~MEDIAN AND ROADSIDE CABLE~~

~~④ ANCHOR BRACKET~~

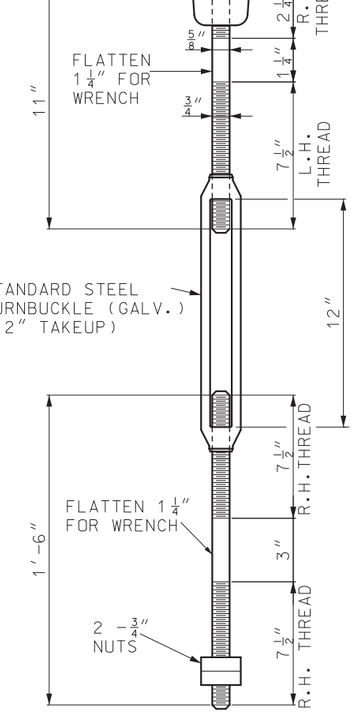


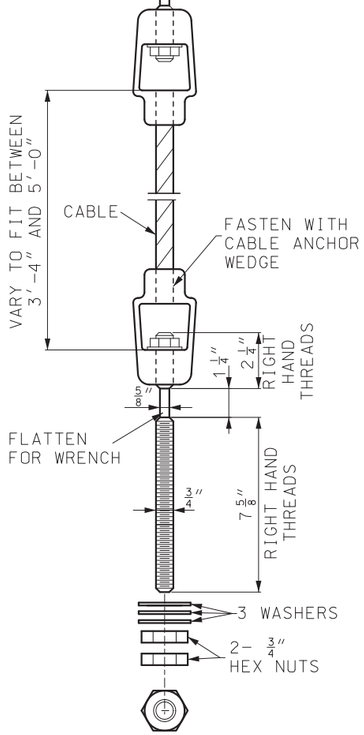

STIFFENER




GUARD CABLE TO GUARDRAIL TRANSITION

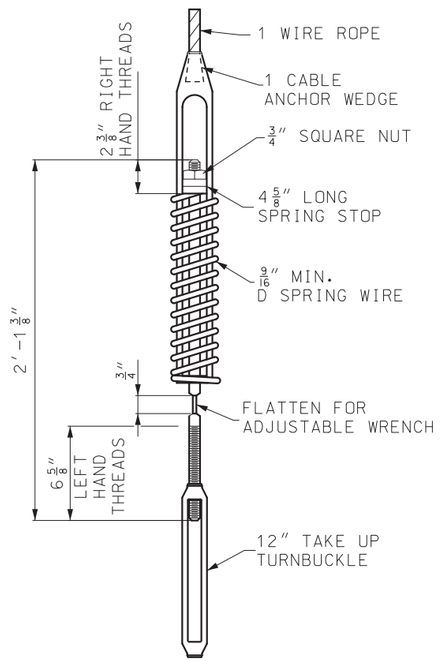



TURNBUCKLE CABLE END ASSEMBLY




CABLE END FITTING

② CABLE END FITTINGS




③ COMPENSATING CABLE END ASSEMBLY

GENERAL NOTES:

~~AT ALL LOCATIONS WHERE THE CABLE IS CONNECTED TO A CABLE SOCKET WITH A WEDGE TYPE CONNECTION, ONE WIRE OF THE WIRE ROPE SHALL BE CRIMPED OVER THE BASE OF THE WEDGE TO HOLD IT FIRMLY IN PLACE.~~

THE SPECIFICATIONS AND DIMENSIONS OF ALL HARDWARE AND FITTINGS SHALL COMPLY WITH AASHTO-AGC-ARTBA JOINT TASK FORCE 13 REPORT, A GUIDE TO STANDARDIZED HIGHWAY BARRIER HARDWARE.



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~~THREE-STRAND~~
GUARD CABLE

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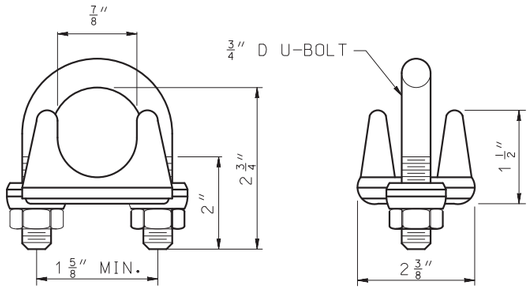
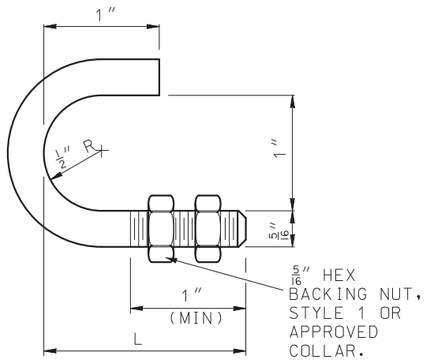
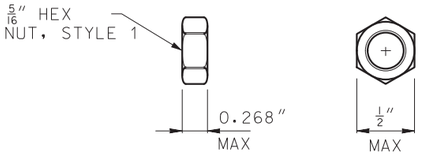
SHEET NO.
6
5 OF 7

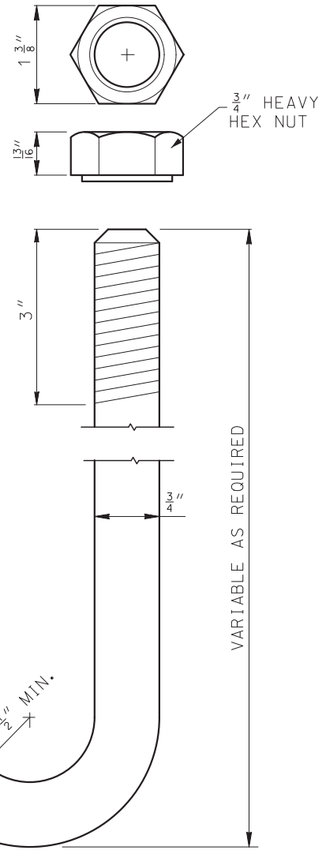



⑤ U-BOLT CABLE CLIPS

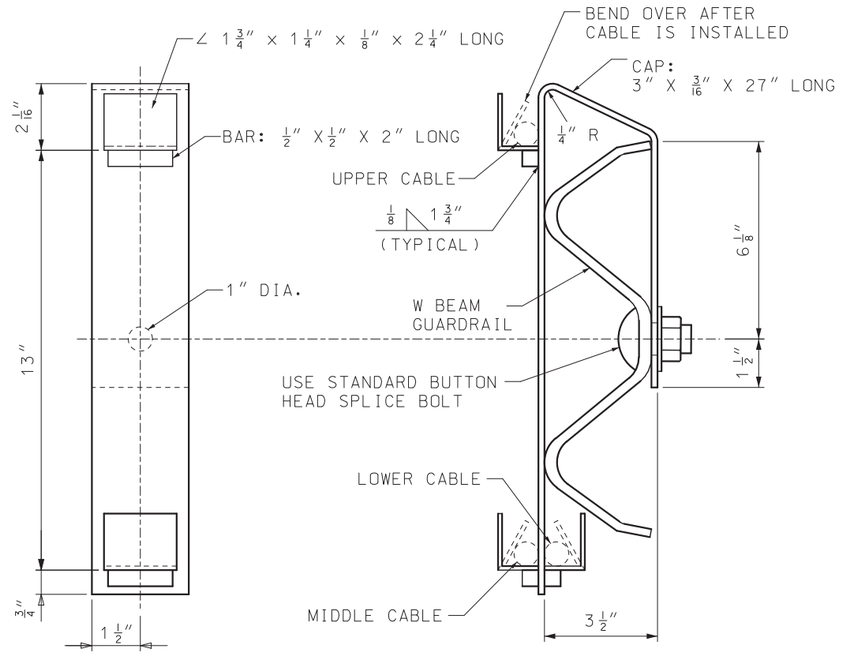


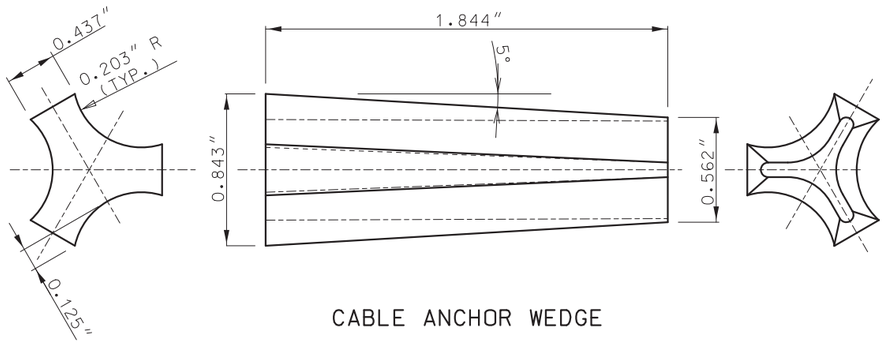

⑥ CABLE HOOK BOLT AND NUT



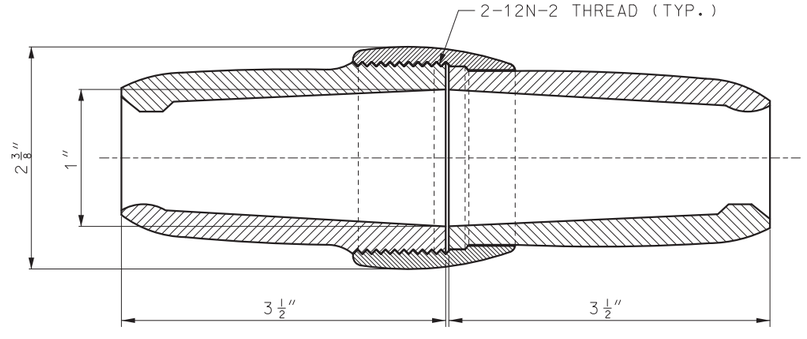

⑦ 25" HOOKED ANCHOR BOLT AND NUT




⑧ CABLE TRANSITION BRACKET




CABLE ANCHOR WEDGE




NOTE:
FITTING SPLICE SHALLDEVELOP THE FULL STRENGTH OF THE CABLE (25,000 LB.).

CABLE SPLICE

Notes:
Repair Splices for low-tension systems will be no closer than 400' and no more than 4 splices per cable within a 2000' run. When a repair to a low-tension cable requires splices closer than 400' or more than 4 splices per cable within a 2000' run, the full 2000' cable length may be replaced with the engineer's approval.

IF A SEAL IS PRESENT ON THIS SHEET IT HAS BEEN ELECTRONICALLY SEALED AND DATED.

MISSOURI HIGHWAYS AND TRANSPORTATION COMMISSION
105 WEST CAPITOL
JEFFERSON CITY, MO 65102
1-888-ASK-MODOT (1-888-275-6636)

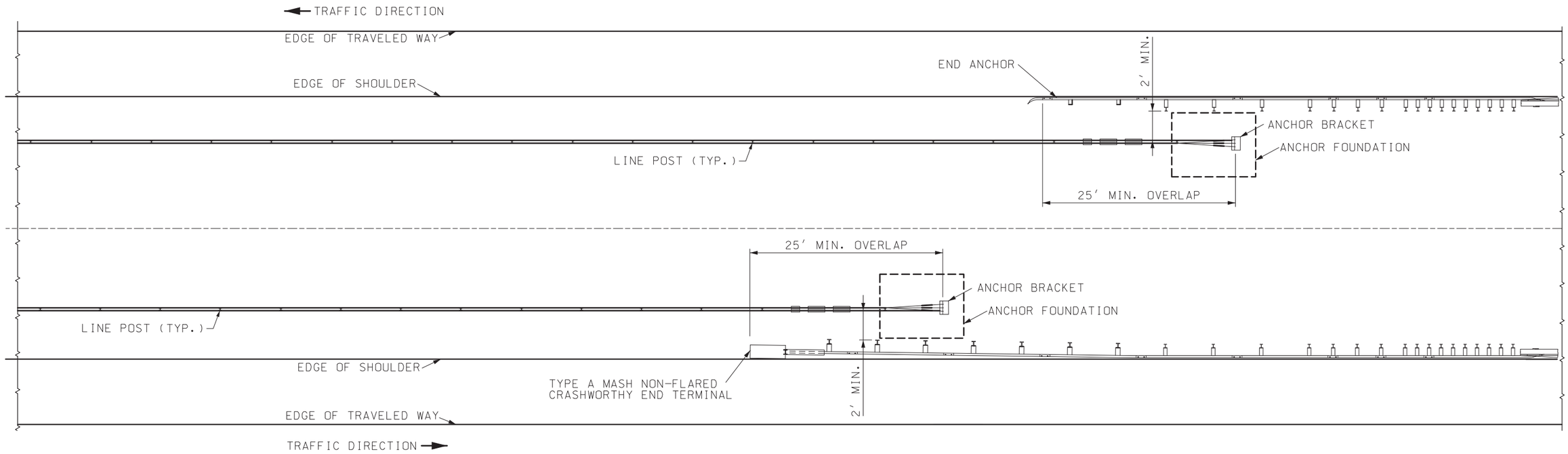
STATE OF MISSOURI
TRAVIS D. KOESTNER
NUMBER PE-30042
PROFESSIONAL ENGINEER
THIS SHEET HAS BEEN SIGNED, SEALED AND DATED ELECTRONICALLY.

# REPAIR ONLY LOW-TENSION ~~THREE-STRAND~~ GUARD CABLE

DATE EFFECTIVE: 04/01/2021
DATE PREPARED: 1/27/2021

606.41M

SHEET NO.
~~7~~ 6 OF 7




GENERAL NOTES:

LINE POST SPACING SHOULD NOT EXCEED 20' OR THE MANUFACTURER'S RECOMMENDATION.

THIS DRAWING DEPICTS THE OVERLAP OF GUARD CABLE AND GUARDRAIL. IT DOES NOT INDICATE THAT TWO RUNS OF CABLE ARE REQUIRED.

REPAIR SPLICES FOR HIGH-TENSION SYSTEMS SHALL BE NO CLOSER THAN 200' PER CABLE WITHIN A 1,000' RUN. WHEN A REPAIR TO A HIGH-TENSION CABLE REQUIRES SPLICES CLOSER THAN 200', A LONGER SECTION MAY BE REPLACED TO REDUCE THE NUMBER OF SPLICES FROM TURNBUCKLE TO TURNBUCKLE WITH THE ENGINEER'S APPROVAL.

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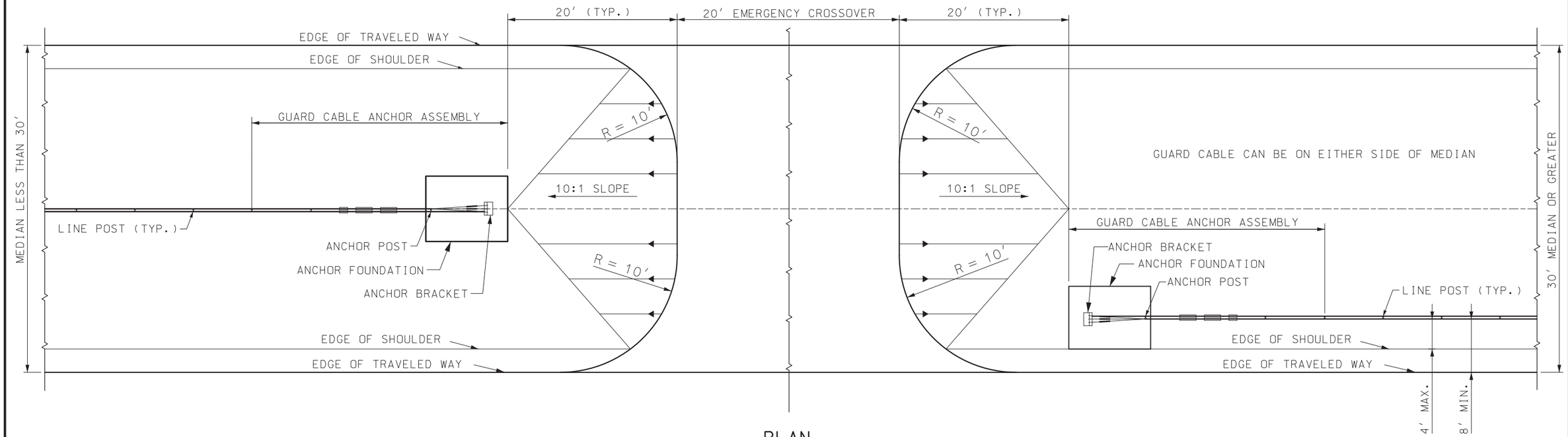
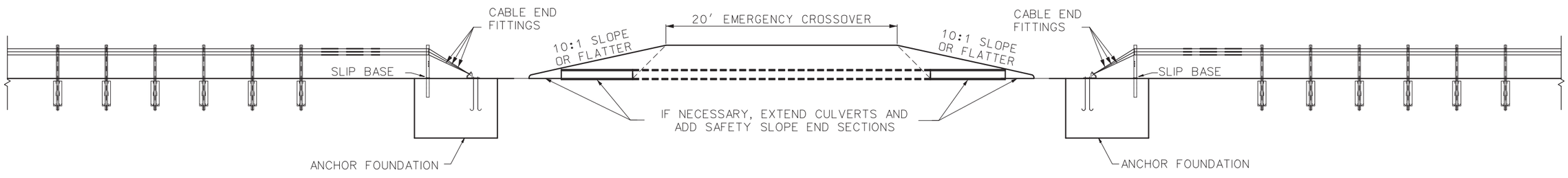
# HIGH-TENSION GUARD CABLE

## TANGENTAIL GUADRAIL OVERLAP

| DATE EFFECTIVE: | DATE PREPARED: | | |
|---|---|---|---|
| 7/1/2024 | 3/22/2024 | 606.42 | SHEET NO. 1 OF 2 |




PLAN




PROFILE

**MISSOURI HIGHWAYS AND TRANSPORTATION COMMISSION**

105 WEST CAPITOL
JEFFERSON CITY, MO 65102
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# HIGH-TENSION GUARD CABLE

## TRANSITION AT MEDIAN OPENING

DATE EFFECTIVE: 7/1/2024
DATE PREPARED: 3/22/2024

606.42

SHEET NO. 2 OF 2

**Category: 1040 Guardrail, End Terminals, One-Strand Access Restraint Cable and ~~Three-Strand~~High-tension Guard Cable Material**

1040.2.5 High-Tension~~Three-Strand~~ Guard Cable System

The components of a ~~three-strand~~high-tension guard cable system will be inspected and accepted in accordance with their applicable specification. However, complete ~~three-strand~~high-tension guard cable systems may~~will~~ be accepted on the basis of the system having successfully completed ~~NCHRP 350~~ MASH-16 Test Level 3 testing~~, and~~ the manufacturer having received a letter of acceptance from the FHWA, and internal approval through MoDOT's MASH Implementation Team~~.~~ A list of qualified ~~three-strand~~high-tension guard cable systems can be found in Qualified Systems for JSP Median Guard Cable FS-1040 Table 8. The manufacturer shall request to be placed on the qualified list by submitting to Construction and Materials a letter stating their request and certifying that their system has completed ~~NCHRP 350~~MASH 2016 Test Level 3 testing, and a copy of the FHWA acceptance letter. Until additional high-tension guard cable systems are approved with MASH-16 TL-3, NCHRP 350 TL-3 are still acceptable and included MoDOT's QPL found at End Terminals, Crash Cushions and Barrier Systems.

1040.5 Laboratory Testing Guidelines for Sec 1040

1040 Guardrail, End Terminals, One-Strand Access Restraint Cable and Three-Strand Guard Cable Material

## 231.1.2 Barrier Types

Concrete barrier and guardrail are best when used on flush medians narrower than 36 ft. Type B guardrail (Standard Plan 606.00) is used in those locations in which a median barrier is to be provided but site conditions will not permit the use of a concrete barrier (drainage, visibility requirements, aesthetics, etc.). Concrete barrier is generally limited to high volume roadways with narrow width medians. When concrete barrier is used, Type C (and Type D as required) is the preferred configuration for new construction. Type A (and Type B as required) are only to be used for new construction projects in a retrofit condition or to "tie in" to existing Type A concrete barrier, which exists on adjoining sections of roadway. An approved crash cushion or sloped end crashworthy end terminal is the required end treatment for concrete barriers. A barrier height transition is not used in locations where the posted speed limit is greater than 35 mph. Where height transitions are used, they are located as far as practicable from the traffic lanes, and if possible, the lead end flared outside the clear zone. Concrete barrier details and barrier height transitions are shown in Standard Plan 617.10. The distance between the left hand edge of the lane next to the median and the face of the concrete median barrier is limited to not more than 15 ft.

Many existing freeways have medians that are more than 36 ft. in width. These medians are of sufficient width to satisfy clear zone requirements, thus making the provision of median barrier optional. While the provision of a concrete barrier or Type B guardrail may not be required at these locations, a ~~three-strand~~high tension guard cable may be desirable. Guard cable is effective is these situations and in locations with cross-median accident history.

606.2.1 Guard Cable Types

Guard cable consists of twisted wire ropes mounted on weak posts. There are two types of guard cable systems in use on Missouri roadways: low-tension and high-tension. All new installations will be high-tension ~~and require NCHRP 350 or MASH TL-3 compliant guard cable systems.~~

606.2.1.1 Low-Tension. ~~Since no single producer exclusively manufactures low-tension guard cable, this system has been commonly called the "U.S. generic" system or non-proprietary. Low-tension guard cables typically consist of three cables placed at different heights and are tensioned to eliminate sag between posts. Large springs at either end of the cable run are compressed, according to temperature, to achieve the system's tension. The cable itself is strung on posts that are directly driven into the ground.~~

~~Typically, when a vehicle impacts the low-tension system, the cable stretches laterally "catching" the vehicle. This movement is known as the dynamic deflection.~~

~~Given the low tension of the system, individual installations, or "runs", of cable are limited to 2000 ft. with an anchor assembly at each end. When a vehicle strikes low-tension cable, the system can become disabled and should be repaired as soon as practical.~~

~~Low-tension systems have proven their value by reducing cross-median incidents. However, the installation of new low-tension cable systems should be limited to small-scale installations.~~ Existing low-tension guard cable may~~can~~ remain in place as long as the guard cable system is in serviceable condition~~serving its intended purpose~~. Low-tension ~~three-strand~~ guard cable shall not be used for new barrier installations. ~~For vehicle incidents with~~ Existing low-tension guard cable ~~the~~ systems~~system~~ may be repaired when damaged (see EPG 606.2.4 Maintenance and Repair) if practical~~ble or replacement with high-strandtension guard cable may be required~~. If not practical, low-tension guard cable may be replaced with high-tension guard cable.

**606.2.1.2 High-Tension.** ~~High-tension cable barrier looks very similar to low-tension cable but the two systems are very different in most other aspects.~~ High-tension guard cable consists of three or four pre-stressed cables supported by weak posts. All high-tension guard cable shall meet NCHRP 350 or MASH TL-3 requirements and be on MoDOT's approved products list End Terminals, Crash Cushions and Barrier Systems | Missouri Department of Transportation (modot.org). All high-tension guard cable shall be installed per ~~manufactures~~manufacturer's requirements.

~~During installation, the cables are placed on the posts and then tightened to the manufacturer's recommended tension. Due to this tightening, the cable installations can be of indefinite length. The runs are typically only limited by the presence of median openings.~~

~~Typically, when a vehicle impacts the high-tension system, the cable, like low-tension guard cable, it will laterally deflect. The inherent tension within the system also allows the cable to remain at the proper height, even after an impact removes several posts. The high-tension system is not designed to continue to function in that this condition, therefore repairs should be made as soon as practical.~~

~~As of 2007, all high-tension guard cable systems are proprietary, that is, marketed under exclusive rights of a specific manufacturer. Five systems are currently marketed in the United States.~~

~~See End Terminals, Crash Cushions and Barrier Systems for the list of approved high-tension guard cable manufacturers.~~

A common installation of high-tension guard cable employs concrete footings into which metal tubes are cast, forming sockets. The socket allows a post to be replaced with relative ease during a repair operation. The damaged post can be removed from the socket and replaced with a new post. Socketed systems eliminate the requirement for specialized post driving equipment and subsurface utility location for each repair.

High-tension guard cable systems can be used on a variety of median inslopes, often eliminating the need for costly slope corrections and drainage modifications.

### 606.2.2 Warrants

Analyses of cross-median incident history and traffic volume provide valuable information in determining the likelihood of future incidents on these routes. In order to prevent future incidents, it is important to focus safety efforts on locations that will benefit the most from safety countermeasures.

The risk of cross-median crashes can be influenced by median width and the traffic volume on both roadways (two-way AADT). Figure 606.2.2 shows various levels for implementation based on the anticipated benefits of reducing crashes compared to costs for installation, maintenance, and overall crash impact. The Highway Safety and Traffic Division may be contacted for additional details on how the anticipated benefits of guard cable installation were determined.

Median guard cable should be installed in Level 1 locations.

Median guard cable may be installed in Level 2 or 3 locations based on engineering judgment. Guard cable may be installed on Level 4, but is not typical and should have additional justification based on the context of the location.

**606.2.2.1 Data.** Analysis of incidents on a candidate corridor should focus on cross-median incidents on that route.

It is important this data analysis is accurate and complete for all roadways. Due to at-grade intersection incidents on these routes, a simple query of cross-median incidents may include unwanted events and exclude necessary ones. Accuracy of this data is vital in decision-making.

The data should be reviewed regularly to validate priorities and identify any emerging cross-median safety concerns. A regular review of divided highway traffic volume and incidents will provide information to address cross-median incidents.

**606.2.2.2 Traffic Volume.** Recent research has connected traffic volume growth directly to cross-median incidents. As volume increases, the probability of a motorist crossing the median and hitting an oncoming vehicle also increases. Instead of relying solely on incident history, there is an opportunity to proactively address this incident type before the incidents occur by studying traffic volume patterns and installing a system of median guard cable on routes with sharply increasing volumes. See Figure 606.2.2 for the anticipated impact traffic volume has on crash risk and anticipated value for guard cable installation.

**606.2.2.3 Median Width.** Recent national experience has shown that cross-median incidents can occur on highways with median widths above MoDOT's initial 60 ft. threshold. Although this width has largely proven to be effective in deterring such incidents, no route will be excluded from analysis solely on the basis of median width. Divided highways with very wide medians are expected to have

a low risk of cross-median incidents. See Figure 606.2.2 for the anticipated impact median width has on crash risk and anticipated value for guard cable installation.

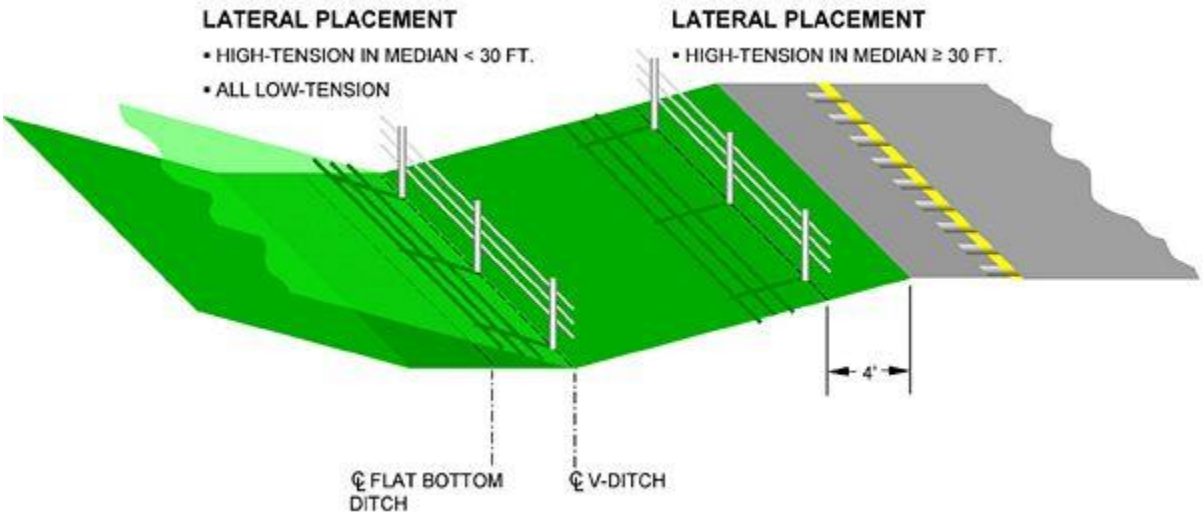
# 606.2.3 Design and Installation Guidelines

**606.2.3.1 Lateral Placement in the Median** [SK1]– Figure notes (In Lateral Placement – All Low-Tension should be deleted)

**Dynamics of Cross-Median Incidents.** When a vehicle leaves the roadway and enters the median, certain predictable dynamics occur. Vehicles may enter the median at a variety of speeds and angles but for the purposes of roadside safety research and testing, a 62 mph departure at a 25° angle is generally used.

Upon departure, a vehicle will initially continue along its vertical trajectory. As the inslope falls away along the 25° vehicle path, the vehicle effectively becomes briefly airborne. When the vehicle's inertia can no longer overcome gravity, it lands and its suspension is deeply compressed. As the vehicle continues to travel through the median, the suspension rebounds and the bumper of the vehicle stays at a relatively constant height throughout the remainder of the errant journey.

Every guard cable incident is slightly different because of a host of site-specific factors. In general, however, the front of the vehicle must engage at least two of the three or four cables present in order to be contained by the system. Given the dynamics described above, lateral placement of the cable can be grouped into two main categories: medians wider than 30 ft. and those narrower than 30 ft.




**Medians 30 ft. or wider.** The guard cable should be installed no more than 4 ft. downslope of the edge of the shoulder. With wider shoulders, the downslope location could be less than 4 ft., but in any case, there shall be a minimum of 8 ft. between the barrier and the edge of traveled way. There are several advantages to this location but chief among them is the performance of the system in a incident. At the 4 ft. downslope location, the errant vehicle adjacent to the barrier, while airborne, is not at a great enough altitude to override the cable during a front side encounter. From the opposing direction, or backside, the suspension of the errant vehicle will have recovered enough to allow an impact to occur under relatively normal impact conditions.

If the 8 ft. separation cannot be obtained, the designer must work with the Central Office Design Division to assess the potential safety impacts of a decreased deflection distance. A different barrier system should be considered.

**Medians narrower than 30 ft.** In medians narrower than 30 ft., the guard cable should be installed within 1 ft. of the vertex of either a V or flat-bottomed ditch. As previously discussed, this location performs the most advantageously. When placed 4 ft. downslope in narrow medians, the suspension of the vehicle impacting from the back side (i.e. the opposite direction) is most tightly compressed near that location. A compressed suspension has potenial to underride the system.

**Alternating Sides.** The designer may choose to alternate the sides of the median where the barrier is placed for the purpose of reducing any shy line issues or discomfort for motorists. The change should occur at natural breaks in the barrier such as emergency crossovers or median bridge columns.

## 606.2.3.2 Parallel Installations

In-service experience with parallel installations has shown less than desirable results. The close proximity of each installation to traffic has caused an inordinately high incidence of nuisance hits resulting in higher than acceptable long-term maintenance costs. Vegetative maintenance is also a concern.

Parallel installations of guard cable should not be used. Instead, designers should rely upon guard cable designed for the situation as a single run or consider a barrier system other than guard cable.

## 606.2.3.3 Post Spacing

While guard cable has been tested and approved with post spacing ranging from 6.5 to 32.5 ft., it is widely believed that the wider post spacing leads to greater deflections and an increased likelihood of vehicle penetration due to underride or traveling between the cables. For this reason, post spacing should not exceed the conventional limit of 20 ft or the manufacturer's recommendation. Additionally, increasing post spacing through horizontal curves increases the opportunity for the cable to assume a chord length if the posts are damaged. If enough posts are damaged, the cable could project into the travelway on the inside of the curve.

## 606.2.3.4 Slopes

Proprietary high-tension systems are approved for use on slopes with gradients between 1V:6H (6:1) to 1V:4H (4:1).

**Anchor Assembly**

## 606.2.3.5 Vegetative Barrier

Vegetation control in the area between the cable and the passing lane should be addressed. Failure to provide some positive form of vegetation control will hinder the future maintenance of the system. The core team shall consult with the local maintenance personnel to arrive at a vegetative control measure that is mutually agreeable. Vegetation control may not be omitted from a project as a practical design or value engineering measure. See EPG 606.2.4 Maintenance and Repair for vegetation maintenance.

## 606.2.3.6 Termination at Crossovers and Emergency Crossovers

The design for guard cable termination as well as the grading for the crossover shall be in accordance with Standard Plan 606.41, Sheet 7 of 7. Refer to EPG 240.4 Guard Cable Termination at Emergency Crossovers for additional information.

### 606.2.4 Maintenance[SK2] and Repair

Guard cable is only as functional as its ongoing maintenance and repair. Proper maintenance and incident repair will ensure that the system is always in a state of functionality to provide motorists a greater level of safety on Missouri roadways.

**Vegetation Maintenance.** District maintenance shall provide vegetative control around guard cable systems. Vegetation maintenance measures should include mowing, herbicides, a geotextile-aggregate strip or an asphalt apron may have been constructed during initial installation.

**Cable Tension.** If pre-stressed cables are used for high-tension systems and compensators are properly compressed for low-tension systems, the tension in the cable should properly acclimate to any weather condition. Tension logs shall be stored in the contract specific eProjects folder. The tension log form is available at EPG 101 Standard Forms.

**Splices.** Repair splices for low-tension systems will be no closer than 400 feet and no more than 4 splices per cable within ~~a~~a ~~-~~2000 foot run ~~of cable~~. When a repair to a low-tension cable requires splices closer than 400 feet or more than 4 splices per cable within a 2000 foot run, the full 2000 f~~ee~~oot cable length may be replaced with the engineer's approval.

Repair splices for high-tension systems will be no closer than ~~every 300 feet for low volume routes such as rural expressways and~~ 200 feet per cable within a 1000 foot run. ~~on routes evaluated for added value with guard cable installation. See Figure 606.2.2 for route evaluation.for high volume routes such as interstate.~~ When a repair to a high-tension cable requires splices closer than 200 feet, a longer section ~~can~~may be replaced to reduce the number of splices ~~following minimum splice spacing guidance or replace the full 1000 foot cable length~~ from turnbuckle to turnbuckle with the engineer's approval. For specific information on MoDOT's approved high-tension guard cable systems, ~~be sure to~~ follow the manufacturer's guidance and guidance within ~~guidelines~~.

**Cable Height.** The importance of cable height to properly capture and redirect errant vehicles has been demonstrated. Although cable height is relatively static in all systems, erosion and tire rutting under the barrier can sometimes cause a localized increase in height, resulting in possible underride. When ditch erosion or rutting causes the cable heights to be outside the manufacturer's recommended maximum, corrective measures should be performed by either the on-call contractor or by in-house Maintenance forces.

Maintenance personnel should be aware of minimum and maximum cable heights and encouraged to identify locations where erosion or the accumulation of silt have altered the relative cable height.

**Median Condition.** The median condition with respect to rutting, loss of vegetation and incident debris should be remedied by Maintenance forces following each incident.

**Guard Cable Repair.** Incident repairs shall be performed by the on-call contractor. See EPG 147.3.10 Guardrail and Guard Cable Repair for additional Job Order Contracting requirements for guard cable repairs.

## 606.2.5 Maintenance Planning Guidelines for Guard Cable

See Maintenance Planning Guideline for Guard Cable.

Index of all Maintenance Planning Guidelines.

## 606.2.6 Construction Inspection Guidelines for Guard Cable

**For Sec 606.50.2**. The embankment slope between the shoulder and the guard cable should be 1V:6H (6:1) or flatter, unless the system is approved for use on slopes as steep as 1V:4H (4:1). If only one run of high-tension ~~three-strand~~ guard cable is installed in the median, the slope on both sides of the guard cable should be 1V:6H (6:1) or flatter, unless the system is approved for use on slopes as steep as 1V:4H (4:1). No exceptions should be allowed unless approved by the Central Office. This is essential for the guard cable to perform as designed.

The embankment slope behind the guard cable is not critical (may be as steep as 1V:2H (2:1)) if another run of high-tensionthree-strand guard cable is installed on the other side of the median to prevent crossovers from that direction of traffic or if adequate clear zone is provided in the other direction of traffic. Such "double runs" are discouraged, however, since both the initial and lifetime costs are doubled.

**Aggregate Bedding (for Sec. 606.50.2.4)**. Predominantly one-sized stone as a bedding material for guard cable, as currently specified in Sec 606.50.4, will act as marbles when a vehicle impacts the bedding material and will likely result in an impacting vehicle to dive under the cable system and continue across the median into the opposing traffic, thereby defeating the purpose of the guard cable system. This is elevated to even a larger safety issue where contractors have provided sand or gravel as the bedding material, which have a greater tendency to roll like marbles when impacted and increases the probability for a vehicle to dive beneath the barrier system. In the interim of getting a specification revision, existing jobs should be change ordered to a bedding material consisting of a uniform, angular graded material of a gradation similar to that shown below. Verification of the gradation should be accomplished by visual inspection, and when in suspect, a sieve analysis should be conducted.

| Sieve Size | Percent Passing by Weight (mass) |
|---|---|
| 3 in. (75mm) | 100 |
| 1 in. (25mm) | 80 |
| No. 4 (4.75mm) | 0-35 |

**Delineators (for Sec. 606.50.2.5).** All high-tensionthree-strand guard cable, regardless of the location of the guard cable, should be delineated, with delineator spacing, reflective sheeting and reflector colors in accordance with Sec 606.10.2.3.

Category:617 Traffic Barrier

Although the cable system is relatively inexpensive to install, when compared with a concrete barrier or Type B guardrail system, and performs well when hit, it must be repaired after each hit to maintain its effectiveness. ~~Especially for low-tension guard cable, this repair must be done as quickly as possible after a hit to ensure the effectiveness of the barrier.~~ Consequently, its use in areas where it is likely to be frequently hit is not recommended. In these situations other types of median barrier are to be considered.

Delete picture below along with picture title/description.

Installing low-tension guard cable

3- or 4- Strand High- Tension Guard Cable Barrier JSP 06-07D

**1.0 Description.** This work shall consist of all labor, equipment, and materials to remove, install, repair, and replace a 3- or 4- strand cable barrier system including all hardware and appurtenances as shown on the plans or as directed by the engineer. The cable barrier system shall function in accordance with the requirements of MASH- 2016 or NCRHHRP 350, Test Level 3, and be approved by the Federal Highway Administration. Test Level 3 acceptable products, for use as a cable barrier system, are included in the list of pre-qualified products displayed on MoDOT's website. Acceptable products shall include galvanized high-tension wire ropes and anchorages. ~~The cable barrier system shall be constructed as shown on the plans, with a maximum deflection of 9 feet.~~

**2.0 Construction Requirements.** Line posts shall be provided in accordance with the manufacture's shop drawings and shall be placed plumb. Spacing of the posts shall not exceed 20 feet.

**2.1 Anchor Assemblies.** An anchor assembly, as specified in the manufacturer's shop drawings, shall be constructed at each end of a cable barrier run. The anchor assembly shall function in accordance with the requirements of MASH -2016 or NCHRRHP 350, Test Level 3, and be approved by the Federal Highway Administration. Anchors shall be constructed on firm, stable, undisturbed soil to the minimum dimension shown on the shop drawings. Anchor bolts and anchor post slip bases shall be firmly held in position at the top by templates during concrete replacement. Backfill shall be thoroughly compacted with mechanical tampers with care taken to prevent damage to the finished concrete. Backfill shall be brought up level with the finished grade line.

**2.2 Cable.** The galvanized wire rope shall be ¾" pre-stretched 3 x 7 construction as approved by the Federal Highway Administration during the system's acceptance testing. Threaded terminals (wedge or swaged type) shall be furnished. Swaged terminals may be shop- or field-swaged. Threaded terminals shall be right hand (RH) or left hand (LH) threaded M 24 x 3 pitch to ANSI B 1.13 M. The body of the threaded terminal shall provide a minimum of 5.9" of wire rope penetration depth. Threaded terminals shall be galvanized after threading to ASTM A 151. Turnbuckle or rigging screws shall be of the size and shape shown in the manufacturer's shop drawings. Rigging screws shall be of a solid or closed body type with two inspection holes to determine threaded rope terminal penetration. Rigging screws shall be galvanized to ASTM A 153 after threading.

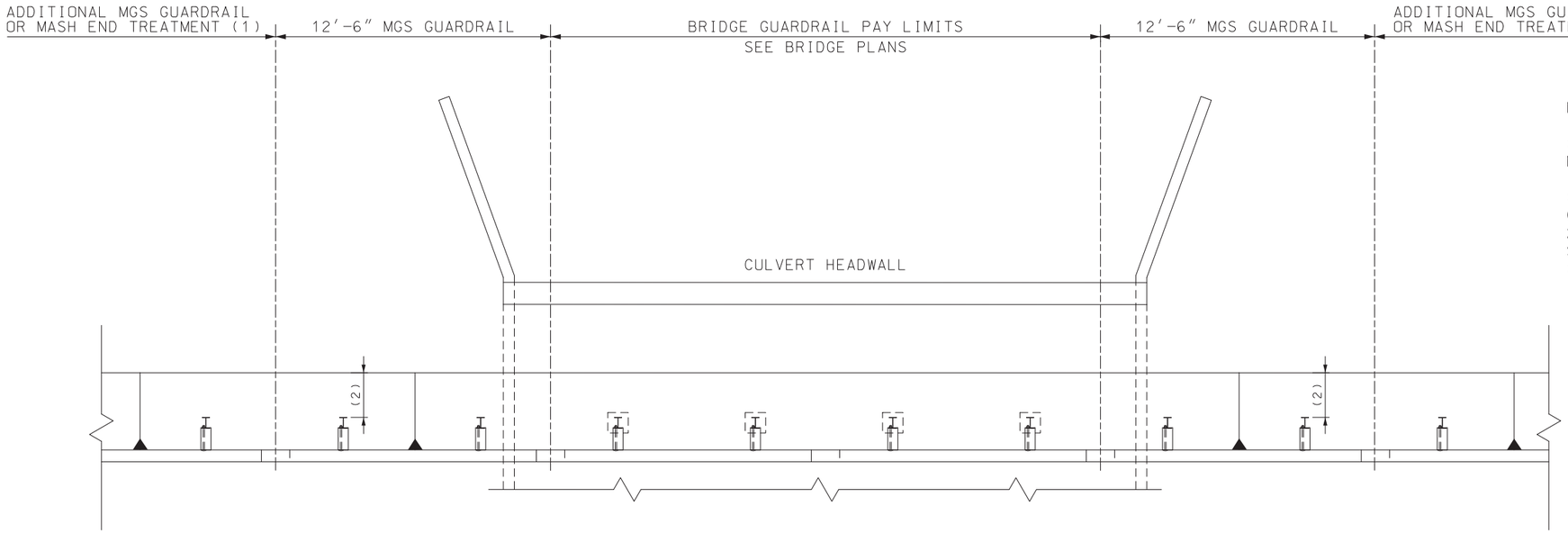
**2.3 Cable Tensioning.** The cable height above ground shall be in accordance with the manufacturer's shop drawings. The cable shall be tensioned immediately after initial installation. Tension shall be rechecked and adjusted, if necessary, three to five days after initial tensioning on cable system sections with lengths greater than 2500 feet. A tension log form shall be completed showing: the time, date, location, ambient temperature and final tension reading, signed by the person performing the tensioning, and furnished to the engineer upon completion of the work. This form shall also include the system manufacturer's recommended tension chart.

**2.4 Delineators.** Delineator spacing and reflector colors shall be in accordance with Sec 606.10.

**3.0 Method of Measurement.** Measurement of the cable barrier will be made from center of line posts, totaled to the nearest linear foot.

**3.1 Anchor Assemblies.** Measurement of anchor assemblies will be made per each.

**4.0 Basis of Payment.** The accepted quantities of cable barrier, anchor assemblies, cable barrier to guardrail interfaces will be paid for at the contract unit price with Item No. 606-99.03 High Tension Guard Cable (per linear foot), Item No. 606-99.02 HTGC Anchor Assembly (per each), and Item No. 606-99.02 Cable to Guardrail Transition (per each). Any anchor assembly required for cable to guardrail transition shall be considered included in the contract unit price for cable to guardrail transition. No direct payment will be made for delineators or setting post in rock.

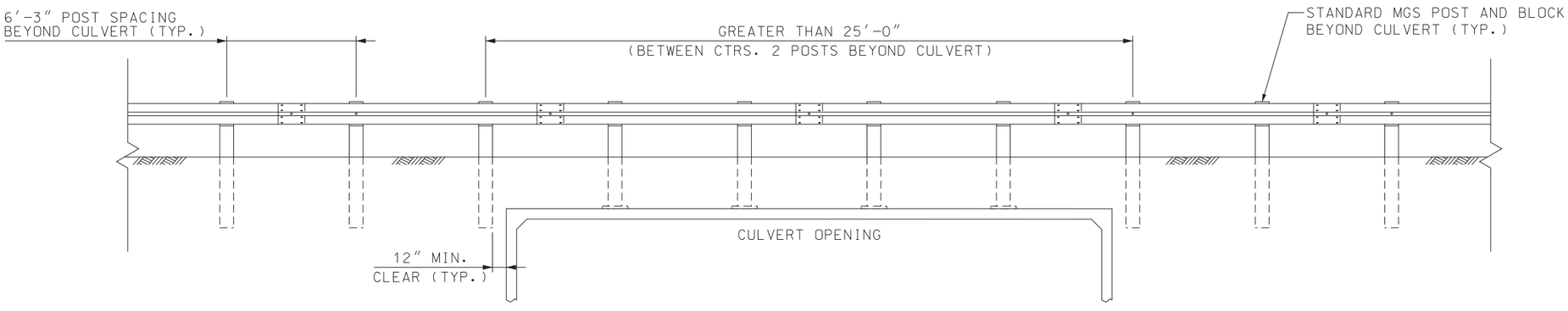



PLAN VIEW

NOTES:

(1) INSTALL A MIMIMUM OF 37′-6″ OF ADDITIONAL MGS GUARDRAIL BEFORE STARTING A TAPER OR RADIUS.

(2) WHEN SITE CONSTRAINTS PROHIBIT OR EMBNAKMENT CANNOT BE BE CONTRUCTED TO PROVIDE A MINIMUM OF 2 FEET BETWEEN THE BACK OF THE GUARDRAIL POST AND SLOPE BREAK POINT. 8 FOOT POSTS SHALL BE USED (SEE SHEET 6 OF 9).




ELEVATION VIEW

MISSOURI HIGHWAYS AND TRANSPORTATION COMMISSION
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# MIDWEST GUARDRAIL SYSTEM (MGS) ON CONCRETE BOX CULVERT

DATE EFFECTIVE: XX/XX/2024
DATE PREPARED: 2/7/2024

606.50F

## 751.1.3.4 Barrier or Railing Type, Height and Guidelines for Curb Blockouts

AASHTO LRFD uses the term “railing” to refer to all types of bridge traffic barrier systems used on bridges. MoDOT uses the term “barrier” for solid concrete bridge railing (single-faced on the edge of roadway and dual-faced medians) and the term “railing” for barrier systems consisting of a rail(s) and supports. Several types of barrier and railing are acceptable for use on bridges in Missouri (see Common Bridge Barrier and Railing); thrie beam railing, Type A, B, C, D, G and H barrier; curb and parapet barrier, two tube rail; or FHWA MASH or NCHRP 350 approved crash tested barrier or railing meeting TL-4 rating as given on the FHWA Bridge Railings website.

While meeting MASH TL-4 requirements is preferred, existing barrier or railing may be used in place if meeting NCHRP 350 TL-3 or TL-4 requirements, or existing barrier or railing may be retrofitted to meet same requirements. See Common Bridge Barrier and Railing (for Rehabilitations) for further guidance.

New bridge barrier or railing on existing bridges shall meet MASH TL-4 requirements on major routes with design speeds greater than 45 mph. Similarly, MASH TL-4 barrier or railing is required on minor and low volume routes with design speeds greater than 55 mph or AADT ≥ 1700. New bridge barrier or railing on existing bridges for all other major, minor, and low volume routes may instead meet MASH TL-3, NCHRP 350 TL-4 or NCHRP 350 TL-3 requirements where circumstances restrict the use of a MASH TL-4 barrier or railing. In any case, the new barrier or railing shall not be rated lower than the existing barrier or railing. The hierarchy for crash test ratings in descending order is listed below with qualified barriers and railings in Missouri:

- MASH (2016) TL-4 (Type C and D barrier, 38-inch two tube railing)
- MASH TL-3 (Type H barrier, Type A and B barrier, culvert guardrail)
- NCHRP 350 TL-4 (32-inch two tube railing, 12” x 29” vertical barrier)
- NCHRP 350 TL-3 (thrie beam railing).

Type C and D barrier shall be used on all redecks, rehabs and widenings where the full length of barrier is being replaced with exceptions for the following:

- sight distance concerns. Type H barrier or two tube rail is recommended.
- rating concerns where the weight of the barrier prohibits its use or causes impractical restrictions or costs for the project. Type H barrier or two tube rail is recommended.
- roadway width restrictions. 32-inch ~~Two~~ two tube rail or thrie beam rail is recommended.

The approach railing does not need to match the test level of the bridge barrier or railing. MoDOT standard approach rails typically do not rate higher than TL-3.

When using a concrete barrier, a five-hole bolt pattern shall be used for connecting the approach railing to the bridge barrier.

Bridge barrier or railing on single lane bridges may be used in place if for no other reason than the grade is not being raised. Thin wearing surfaces measuring no more than 3/8 inch will not be considered as raising the grade.

**Thrie Beam Railing (Bridge Guardrail)**

If the deck is less than 8½ inches thick, the attachment must bolt through the deck with a plate on the bottom side of the deck. In the past, MoDOT used details where a bent stud was formed within the deck. This is no longer acceptable because of observed failure in thin decks where the edge can break off and the bottom of slab can pop out during a collision.

The center of the thrie beam shall be a minimum of 21 inches to the top of the finished driving surface.

Thrie beam railing shall not be installed on new or replacement bridges or widenings. Thrie beam shall not be used for grade crossings or other areas where drainage over the side of the deck is a concern.

**W-beam Railing (Culvert Guardrail)**

The MASH TL-3 standard for guardrail attachment is covered in EPG 751.12.6 Culvert Guardrail (Top Mounted). Existing guardrail or thrie beam attachments likely do not have an adequate base plate design, railing height or headwall clearance to be considered MASH TL-3 compliant. Existing attachments most closely fit NCHRP 350 TL-3 or MASH TL-2. Existing guardrail attachments shall be treated in the same manner as free-standing guardrail when determining if the system can be used in place (see EPG 606.1.3.1 Guardrail Selection and Placement). If Midwest Guardrail System (MGS) is required and space is available for headwall clearance, 2'-10" minimum between headwall and roadway face of guardrail, the MASH TL-3 standard for guardrail attachment shall be used.

If there is less than 2'-10" of space between headwall and roadway face of guardrail, a thrie beam shall be used and it is preferrable to top mount the headwall instead of pushing the slab mount closer to headwall. The condition of the headwall should be considered before choosing the headwall mount option.

If the top slab is less than 10 inches a bolt-thru attachment is required. For thicker slabs a resin-anchor system is available with a minimum 8-inch embedment. There are advantages to both systems. A bolt-thru attachment provides a stouter connection which may reduce the damage to the culvert slab after impact. On the other hand, repairing a bolt-thru system requires access inside the culvert while a resin-anchor system requires access to top of culvert only. Resin-anchor systems may also be preferred if culvert walls interfere with post placement.

**Type A, B, C, D, G and H Barriers**

If installed at the same time as the driving surface, the top of the barrier shall not be less than 32 inches above the driving surface.

If a wearing surface is installed after the barrier is in place, the wearing surface thickness shall not be made greater than that whereby the barrier height is made less than 30 inches , i.e. the final grade with wearing surface installed shall not increase more than 2 inches.

If an existing wearing surface is replaced next to Type A or B barrier, the new wearing surface thickness shall not be made less than that where by the height above the driving surface of the break between the upper and lower slope of the barrier is made greater than 13 inches.

**Curb and Parapet Barrier**

The concrete portions of the curb and parapet are the only components used in determining the height of the barrier for establishing if the system meets current standards or is substandard. The handrails are not crashworthy and therefore are not considered as part of the height of the barrier.

Curb and parapet were typically constructed 27 inches measured from the driving surface to top of parapet.

Sections of curb and parapet may be replaced without consideration of upgrading.

When a wearing surface is to be applied, the height of the existing curb and parapet system shall be determined from the existing driving surface and if necessary shall be heightened to 32 inches or 36 inches above the proposed driving surface based on Guidelines for Curb Blockout, immediately below. Increasing the height of an existing curb and parapet is generally done by adding a blockout to the curb and parapet (i.e., curb blockout).

**Guidelines for Curb Blockout**

Background and Application

Guidelines were developed considering Practical Design concepts (refer to EPG 143 Practical Design).

Guidelines apply to bridges to be resurfaced and/or rehabilitated that have concrete curb and parapet barrier. They do not apply to bridges on Contract Leveling Course projects that are in accordance with EPG 402.1 Design of Leveling Course Projects.

When resurfacing and rehabilitating a bridge, consideration shall be given to upgrading the curb and parapet barrier by increasing the overall height if the barrier does not meet criteria given in these guidelines. The guidelines are based upon reviewing conditions that require satisfying height and horizontal parapet offset requirements using the minimum height of 27 inches in accordance with 2002 AASHTO 17th Edition and earlier editions and a maximum horizontal parapet offset of 6 inches from curb face to parapet face which is a MoDOT requirement (EPG 128 Conceptual Studies, 3R-Rural Design Criteria recommends a 6-inch brush curb). Upgrades to curb and parapet should be made by constructing a curb blockout. The following guidelines describe circumstances where it is, or is not, necessary to upgrade curb and parapet that were either originally built substandard or made substandard due to an earlier wearing surface or will be made substandard due to a proposed wearing surface.

Guidelines

Look at the 5-year history of accidents on the bridge (beginning log mile to ending log mile).

If there were any accidents in this time period that involved a vehicle *striking the curb*, then curb and parapet not meeting current standards should be upgraded to meet the current (2016) MASH TL-4 requirement which is to increase the height to 36 inches. A 32” blockout height will be allowed, upon approval of the SPM or SLE, when either sight distance or weight restrictions are a concern.

If there were NOT any accidents in the 5-year history AND if the grade is not being raised then it shall not be necessary to upgrade the curb and parapet.

If the accident history or grade criteria are not met, then it shall be necessary to upgrade the curb and parapet. The district may submit a design exception to eliminate a curb blockout for bridges not on major routes and with AADT < 1700 when there is no history of accidents on the bridge and the grade is being raised no more than 2 inches from the 27-inch minimum height requirement.

Limiting Wearing Surface Thickness To Meet Guidelines

The wearing surface thickness can be limited to that which would not cause the curb and parapet height to become substandard. An exception to this is a 1/4 to 3/8-inch height tolerance to allow for the possibility of placing a thin wearing surface on a bridge with an existing standard 27-inch high curb and parapet as measured from the original driving surface to the top of the parapet. Adding a thin wearing surface will not by itself make a satisfactory curb and parapet railing height substandard as reviewed and approved by MoDOT and FHWA. For overlay projects, where a curb blockout is already in place, the final blockout height shall not be less than 30 inches.

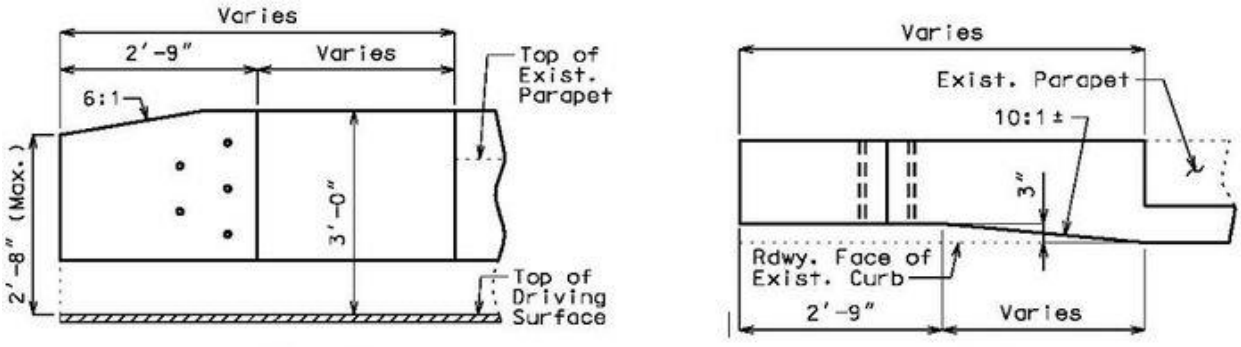
Note: In all cases, the allowable wearing surface thickness would also be dependent on a structural review to confirm that the weight of the wearing surface would not lead to overstresses or an unacceptable posting.

Details

The horizontal offset (or ledge) from the curb face to the parapet face is recommended to be between zero and 3 inches but shall not exceed 6 inches. If a curb blockout is used, the ledge shall not exceed 3 inches.

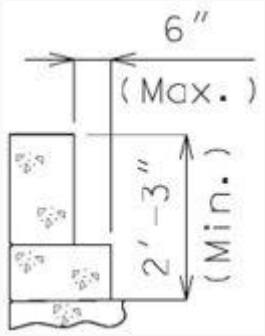
End posts are not always the same width as the parapets. If the end posts are wider and if they extend towards the driving lanes, it shall be necessary to remove the end posts completely in order to construct the curb blockouts. If end posts extend towards the outside of the bridge, it may not be necessary to remove the end posts.

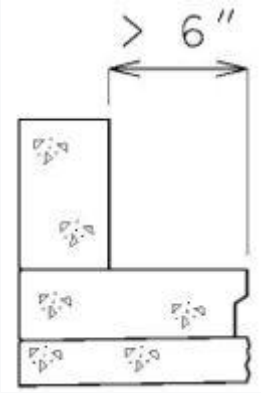
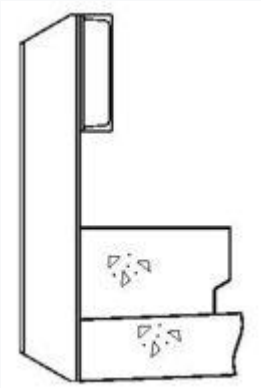
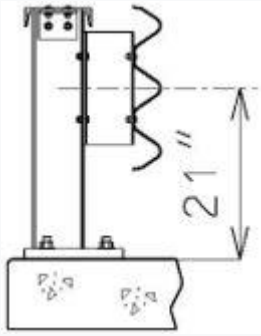
The end treatment for the 36-inch blockout will require a maximum 6:1 slope to transition down to a maximum 32-inch end height near the guardrail attachment. A 32-inch blockout does not require a reduced height for the end treatment. The preferred end treatment will include a gradual width transition that approximates a 10:1 slope. A block inset for the guardrail attachment should be avoided.

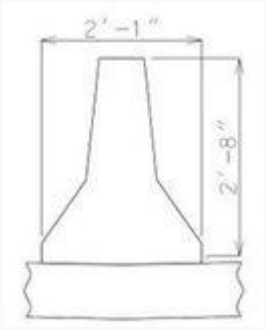
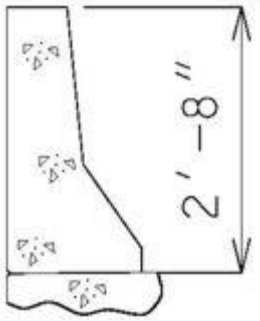
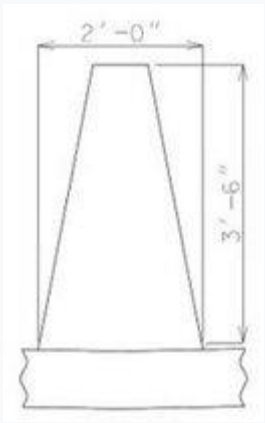


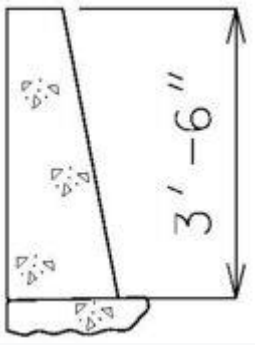
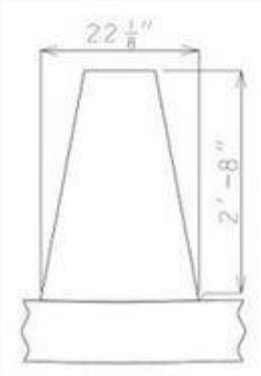
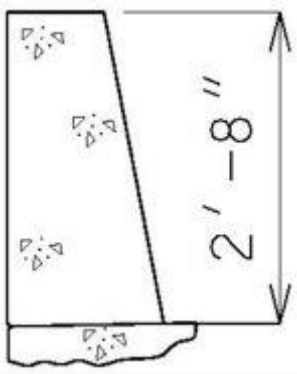

**End Transitions**

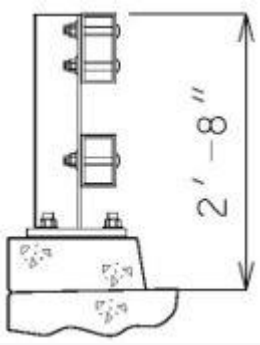
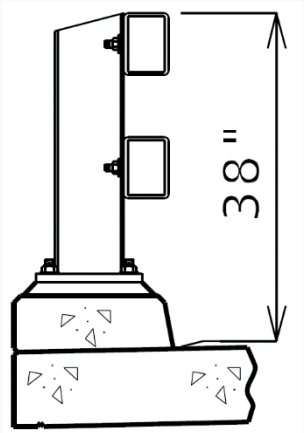
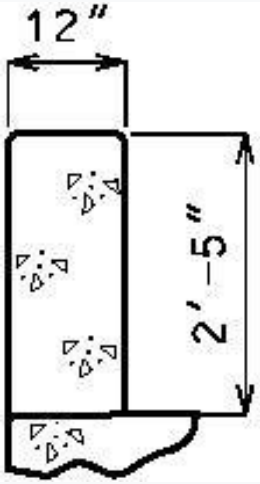
**Common Bridge Barrier and Railing (for Rehabilitations)**

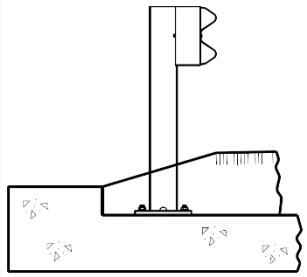
| Type | Section (Test Level) | Allowed Wearing Surface | Required Retrofit | Notes |
|---|---|---|---|---|
| **Curb and Parapet** (Brush Curb ≤ 6”)  |   (N/A) | 3/8” Thin Wearing Surface | Use in place with curb blockout for wearing surfaces greater than 3/8” from original deck surface | (1) |

| | | | | |
|---|---|---|---|---|
| **Curb and Parapet**<br>( Brush Curb > 6”)<br>  |  <br>(N/A) | None without retrofit | Use in place with curb blockout (preferred) or thrie beam railing. | (1)<br>Horizontal step must be 6” or less to be UIP. |
| **Brush Curb with Steel Rail**<br>  |  <br>(N/A) | None without retrofit | Use in place with added curb blockout (preferred) or thrie beam railing. | (1)<br>A variety of steel railing systems were employed on brush curbs. None are acceptable without retrofit. |
| **Thrie Beam**<br>  |  <br>(NCHRP 350 TL-3) | 21” (Min.) from centerline of thrie beam to top of wearing surface | Use in place if minimum height to centerline of thrie beam is acceptable. | (2) and (4)<br>May be embedded or bolted thru. W6x15 blockout is included for all new construction. Non-blocked railing may be used-in-place when no approach guardrail is provided. |

| | | | | |
|---|---|---|---|---|
| **Type A Barrier**<br>(Photo not available) |  <br>(MASH TL-3) | Up to 2” | Use in place. | (1) |
| **Type B Barrier**<br>  |  <br>(MASH TL-3) | Up to 2” | Use in place. | (1) |
| **Type C Barrier**<br>(Photo not available) |  <br>(MASH 2016 TL-4) | Up to 6” | Use in place. | (3)<br>Wearing surfaces greater than 3” require a bridge rating analysis |

| | | | | |
|---|---|---|---|---|
| **Type D Barrier**<br>  |  <br>(MASH 2016 TL-4) | Up to 6” | Use in place. | (3)<br>Wearing surfaces greater than 3” require a bridge rating analysis |
| **Type G Barrier**<br>(Photo not available) |  <br>(MASH 2016 TL-3) | Up to 2” | Use in place. | (3)<br>Use if Type C is considered impractical. |
| **Type H Barrier** |  <br>(MASH 2016 TL-3) | Up to 2” | Use in place. | (3)<br>Use if Type D is considered impractical. |

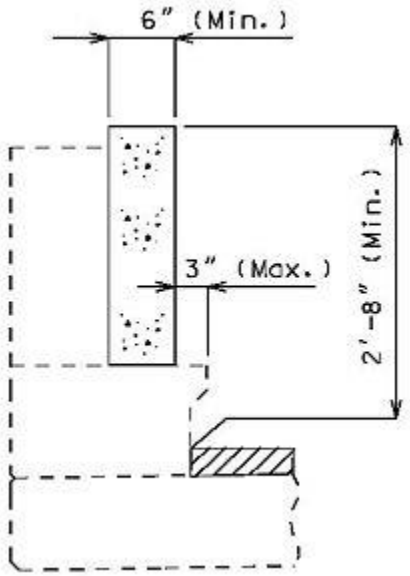
| | | | | |
|---|---|---|---|---|
| **~~Steel~~ 32-inch Two Tube Rail**<br>  |  <br>(NCHRP 350 TL-4) | Up to 2" | Use in place. | (3) and (4)<br>~~A 42" two tube rail has been successfully crash tested for TL-4, but an end treatment has not been approved for use.~~ |
| **38-inch Two Tube Rail**<br><br>**(Photo not available)** |  <br>(MASH 2016 TL-4) | Up to 2" | Use in place. | (3)<br><br>Not for use with turned-back abutment wings less than 18" thick. |
| **12" x 29" Vertical Barrier**<br>  |  <br>(NCHRP 350 TL-4) | Up to 2" | End of barrier modification for new guardrail attachment. | (1) |

| | | | | |
|---|---|---|---|---|
| **Culvert Guardrail** |  (NCHRP 350 TL-3 Thrie Beam or W-beam)[DMB1][DK2] | sSee EPG 606.1.3.1 Guardrail Selection and Placement | Use in place. | If MGS is required for the approach, the MASH TL-3 standard shall be installed if space allows. |
| (1) Shall not be used for redecks, widenings, and railing or cantilever full length replacements.<br>(2) Typically specified for redecks, and railing or cantilever full length replacements. Shall not be used for widenings.<br>(3) Typically specified for redecks, widenings, and railing or cantilever full length replacements.<br>(4) Shall not be used on major routes with design speeds greater than 45 mph or on minor and low volume routes with design speeds greater than 55 mph or AADT ≥ 1700. May be used for all other major, minor, and low volume routes. | | | | |

Aluminum handrail is not crashworthy and does not contribute to barrier height. Use only the concrete portion.

Many other, less common, barrier and railing systems have been constructed. Most are not crashworthy for rural highway speeds. Generally, the replacement of the existing barrier or railing is the only means to upgrade.

For additional information on curb blockouts, see Guidelines for Curb Blockouts.

A curb blockout is utilized along full length of the curb. Bridge Division provides plans for curb blockouts.

# 751.8.3.5 Miscellaneous

### Granular Backfill

The contractor shall furnish granular backfill in accordance with Sec 206 within the limits as shown on the plans when approved by the Engineer. Payment for removal of inherently unsound material will be made at the contract unit price for Class 4 Excavation. The contractor will be reimbursed for the delivered cost of granular backfill when approved by the engineer.

### Wing Backfill Slope Transition

Backfill slope transition at wings is determined based on skew angle of box culvert. See Sheet 2 of 2 in Standard Plan 703.37 for slope transition.

### Culvert Extensions

When an existing culvert is to be extended, cutting details shall be followed to determine where and how to cut the existing culvert. See Standard Plan 703.38 for cutting details.

A transverse joint is not required when extending the barrel not more than 15 feet. When extensions exceed 15 feet, transverse joint requirements are the same as those for full culverts, see EPG 751.8.3.1.

### Guardrail Attachments

When guardrail attachments are required for new culverts they shall be in accordance with EPG 751.12.6 Culvert Guardrail (Top Mounted). When attaching guardrail to an existing culvert follow the guidance outlined in EPG 751.1.3.4 Barrier or Railing Type,Height and Guidelines for Curb Blockouts.

# 751.12 Barriers, Railings, Curbs and Fences

Jump to navigationJump to search

To be found eligible for Federal-aid funding, new roadside safety devices should meet the crash test and evaluation criteria contained in the American Association of State Highway and Transportation Officials' (AASHTO) Manual for Assessing Safety Hardware (MASH). Since neither FHWA nor AASHTO has a system in place to approve roadside devices, the responsibility is left with the States. In response, MoDOT has developed a MASH Implementation process. All roadside devices that are submitted after November 1, 2019, will be reviewed by the MASH Team for approval to use on Missouri roadways. Prior to November 1, 2019 roadside devices were considered using the criterion set forth in NCHRP Report 350 "Recommended Procedures for the Safety Performance Evaluation of Highway Features". While MASH requirements are only applicable to the NHS, the following guidelines are recommended for all bridges.

See SEG 21-01, Anchoring Barriers Over Precast Panels.

AASHTO LRFD uses the term "railing" to refer to all types of bridge traffic barrier systems used on bridges. MoDOT uses the term "barrier" for solid concrete bridge railing (single-faced on the edge of roadway and dual-faced medians) and the term "railing" for barrier systems consisting of a rail(s) and supports.

**Contents**

# 751.12.2 Two Tube Rail (Top Mounted) ~~TL-4 (NCHRP 350)~~

**38-inch Two Tube Rail**

Consult the Structural Project Manager prior to use due to cost.

- Meets TL-4 (MASH 2016)
- May be used for decks not less than 6-1/2 inches.
- Uses an 18-inch wide curb. If the abutment uses turned-back wings they must be 18-inches thick.
- Acceptable for use when site distance is a concern.
- Requires the 38-inch Two Tube Rail Transition for the bridge approaches. See STD. Plan 606.61.

**32-inch Two Tube Rail ~~Guidance~~**

Consult the Structural Project Manager prior to use due to cost.

- Meets TL-4 (NCHRP 350)
- Typically used on redecks, widenings, and railing or full-length cantilever replacements where the 38-inch Two Tube Rail is not practical.
- May be used on adjacent box beam bridges where reinforcement is embedded in the beam.
- Acceptable for use when roadway width or site distance is a concern.
- See EPG 751.1.3.4 Barrier or Railing Type, Height and Guidelines for Curb Blockouts for additional requirements for design speed and AADT.
- Curb is intrinsic to TL rating and shall be used. Curb shall be used to prevent drainage over deck.

- Requires a Bridge Anchor Section (STD. Plan 606.22) for bridge approaches minus the bearing and connector plates.

**Details**

| Bridge Standard Drawings |
| --- |
| Two Tube Rail |

==========

# 751.12.6 Culvert Guardrail (Top Mounted)

**New Culverts**

When a guardrail attachment is required for a new culvert, the guardrail shall be in accordance with the MASH TL-3 standard linked below. Listed below are a few of the requirements to meet MASH TL-3:

- 31-inch railing height measured between top of rail and finished grade
- 9 inches of minimum earth fill at back face of post
- 10-inch minimum clearance between headwall and post
- Guardrail shall be used on a maximum 10:1 slope. The 10:1 slope should be continued a minimum of 2 feet behind the post before using a steeper slope break.
- 6'-3" max post spacing
- Four 7/8-inch bolt pattern with 9-inch spacing in base plate
- 8-inch minimum embedment for resin-anchor option in 4 ksi concrete
- W6x9 steel post (W6x8.5 may be substituted)
- Specify Grade 36 steel for posts and base plates to match approach guardrail specifications. Anchorage is designed to resist forces for grade 50 substitution.

Note: The 10-inch minimum clearance to headwall is to ensure the post does not contact the headwall during a collision which may create a snag point for vehicles.

Provide standard drawing link here

**Existing Culverts**

See EPG 751.1.3.4 Barrier or Railing Type, Height and Guidelines for Curb Blockout for culvert guardrail guidance.

## H9. Thrie Beam and Other Rail Types (Notes for Bridge Standard Drawings)

**Place in General Notes on the rail sheet unless otherwise specified.**

**Notes (H9.1a) thru (H9.67)**
**not shown due to no changes**

**Culvert Guardrail (Also use H9.6.1, H9.12, H9.17)**

**(H9.70)**

Furnishing and Installing posts and guardrail on culvert as shown on this sheet will be considered completely covered by the contract unit price for Bridge Guardrail (W-Beam).

**(H9.71)**

Furnishing and Installing posts and guardrail on culvert shall be in accordance with Sec 606 except as shown.

**(H9.72) Use for bolt-thru option**

Holes for ASTM A307 bolts may be drilled into the culvert.

**(H9.73)**

See Missouri Standard Plans drawing 606.50 for details not shown.

Category:612 Impact Attenuators

Jump to navigationJump to search



**Protective vehicle with a truck-Mounted Attenuator and Flashing Arrow Panel**


~~Safety Videos~~

~~2014 TMA Safety Points~~

~~The traffic control guidance of the EPG serves as MoDOT's Manual on Uniform Traffic Control Devices (MUTCD) and should be used as the primary document when applying traffic control guidance to MoDOT's roadways. Per federal regulations, MoDOT's traffic control policies are required to be in substantial conformance with the MUTCD. There are occasions in the MUTCD where more than one traffic control device can be applied, but the EPG guidance typically selects the most applicable option for use on MoDOT roadways. The EPG also omits content from the MUTCD which doesn't apply to Missouri.~~

~~Like the MUTCD, the~~ MoDOT's ~~traffic control guidance of the EPG is permissive guidance, meaning this guidance outlines what is permissible~~ allowed ~~in regard to~~regarding ~~applying traffic control devices to MoDOT roadways. When~~ a ~~non~~typical situation ~~specific traffic control guidance is not found~~ refer to the ~~in the Manual on Uniform Traffic Control Devices (MUTCD) or~~ in the EPG, contact the ~~District Work Zone Coordinator or MoDOT Central Office~~ Highway Safety and Traffic Division office for assistance. ~~The Division office can obtain assistance from FHWA, research facilities and other states for possible solutions that are MUTCD compliant. If these solutions have the possibility of being applicable to more than one site, consideration will be made to include the solution into the standard guidance found in the EPG as a standard.~~

~~This article provides information for the use of protective vehicles and three primary types of impact attenuators: truck-mounted attenuators, trailer-mounted attenuators~~ (TMA) ~~and freestanding impact attenuators (sand barrels).~~ Impact attenuators are designed to absorb energy of an impacting vehicle and reduce the force on a passenger ~~to an acceptable level~~. Types of impact attenuators include: truck - mounted attenuators (TMA), freestanding impact attenuators (sand barrels), and work zone crash cushions.

**Contents**

~~612.1 Protective Vehicles/TMAs (MUTCD "Shadow Vehicle")~~

~~Protective vehicles/TMAs are used to safeguard the workspace from errant vehicles. In some operations, these devices also serve as platforms for signs and other devices used to warn traffic of upcoming conditions or inform them of needed actions. For increased motorist, driver and worker safety, the protective vehicle may be equipped with a truck-mounted attenuator~~TMA~~.~~

~~Protective vehicle can be any MoDOT fleet vehicle except for a tractor.~~

~~Proper p~~Positioning of the protective vehicle/TMA vehicle within the work zone is critical to its effectiveness~~. The operator will refer to the appropriate typical application for guidance and placement of the protective vehicle. It is the operator's responsibility to make sure that the protective vehicle/TMA is in the proper position to protect the crew, to provide ample roll-ahead distance, and to provide adequate warning to your co-workers and traveling public.~~

| ***Pros and Cons of Truck- and Trailer-Mounted TMAs*** | | | |
|---|---|---|---|
| **Truck Mounted TMA<br>Host Vehicle 16,000 lbs GVWR** | | **Trailer Mounted TMA<br>Host Vehicle 10,000 lbs GVWR** | |
| **Pros** | **Cons** | **Pros** | **Cons** |
| Cost and Maintenance | | Cost and Maintenance | |
| After an impact the TMA is easily secured to the host truck, for transport to shop *(Ex: no need for a tow truck)* | After impact, damage to host truck is common and extended down time of truck is possible. This may be an issue if the vehicle fleet in an area is low. | For the "boat" trailer style, the TMA normally has less parts, maintenance cost, and assembly cost. | Tire issues can cause down time |
| No tire maintenance or down time due to tire issues | Maintenance can be costly and timely | - | - |
| - | TMA must be removed prior to Arrow Board maintenance or repairs | - | - |
| Operations | | Operations | |
| Follows directly behind truck *(Ex: Will not track paint from striping operations)* | Difficult to remove and install. *(Ex: Truck cannot be quickly used for other applications)* | Trailer TMA are usually easier to install and remove from the truck hitches. | The driver may have difficulties backing, a spotter is recommended. *(Ex: Backing up to pick up channelizers within a work zone and keeping the trailer out of the travel lane)* |
| Easy Backing when spotter not available *(Ex: During work zone removal)* | Difficult to access plugs, wires and lighting connections during installation and removal | After an impact, the trailer is removed from host vehicle and the truck is usually still serviceable. | After an impact, the trailer needs towing by flat bed back to shop for repairs based on manufacturer recommendations |

| | | | |
|---|---|---|---|
| ~~Easy Maneuvering~~ | ~~Truck may not have hitch. This may limit the number of applications of the truck.~~ | ~~-~~ | ~~During operations such as striping, tires can track paint~~ |
| ~~-~~ | ~~When in the down position, the TMA will swing in to adjacent lane~~ | ~~-~~ | ~~Finding a location to turn around can be difficult *(Ex: Rural areas with narrow lanes, small entrances, etc.)*~~ |
| ~~Other Considerations~~ | | ~~Other Considerations~~ | |
| ~~-~~ | ~~Overhead hazards become an issue when the TMA is in the Up position, which reaches 13'6".~~ | ~~When the TMA is not deployed as a protective truck, the tailgate can be left attached for cargo/material hauling.~~ | ~~Depending on the TMA, the unit may rotate into an adjacent lane upon a side impact.~~ |
| ~~-~~ | ~~Due to added weight of the TMA on rear of the truck, the ride is rough and is tough on truck suspension.~~ | ~~The TMA can be used with different host vehicles and is not dedicated to one vehicle.~~ | ~~Some trailer TMAs look similar to "boat" trailers, which give a perception the TMA units are not safe.~~ |
| ~~-~~ | ~~Due to the over swing and lowering of the TMA, the area behind the truck should be clear of personnel and vehicles.~~ | ~~-~~ | ~~-~~ |

**612.1~~.1~~ Truck- ~~and or~~Trailer ~~-~~Mounted Attenuators**

Truck or~~/Trailoe~~r-mounted attenuators (TMAs) are energy-absorbing devices attached to the rear of ~~the trucks and used asa~~ appropriate protective vehicle~~s, thus protecting the motorist and the protective vehicle's driveroperator upon impact~~. ~~The MODOT TA article 616.8 expands upon which work locations require the use of a TMA attached to a protective vehicle.~~ The protective vehicle that supports the TMA must meet manufacturer specifications.

~~Trailer-Mounted Attenuator~~

The National Cooperative Highway Research Project 350 (NCHRP 350) and the 2016 AASHTO Manual for Assessing Safety Hardware (MASH 2016) set the crash criteria for TMAs. ~~TMAs purchased by MoDOT meet these requirements.~~ Non MASH 2016 impact attenuators manufactured prior to January 1, 2023 may be used until January 1, 2030. All impact attenuators manufactured after January 1, 2023 shall meet MASH 2016 Test Level 3 crash test requirements.

Damaged TMAs are to be removed from service and either repaired or replaced. ~~Articles on MoDOT's are available upon request.~~

~~NCHRP 350 and MASH 2016 crash tests straight on and offset collisions, not side impacts. TMAs are not designed for side impacts.~~

~~Articles on MoDOT's~~ Maintenance Planning Guidelines for Impact Attenuators ~~are available upon request.~~

**612. ~~1.2~~1.1 MoDOT ~~Protective Vehicle/~~TMA Marking, ~~and~~ Emergency Alert Lights~~Lighting~~, and Audible Alert System**

While in the operating position, the rear facing of the TMA shall be marked with alternating 8-inch yellow and 8-inch black retroreflective sheeting forming an inverted "V" at the center and slope downward at an angle of 45 degrees toward each side of the unit or a checkered board pattern consisting of 12- inch square red and 12-inch square white retroreflective sheeting. The TMA may be marked with the same operating pattern or red and white DOT conspicuity tape to simulate the looks of a standard van body trailer when traveling.

~~For future installations beginning July 1, 2023~~, ~~uUse~~ Emergency Alert Lights (EALs) and Audible Alert systems on ~~all~~ MoDOT MASH 2016 tested TMAs are used in accordance with typical applications. ~~Install EALs below the flashing arrow panel.~~

All lighting should be appropriately set, depending on the day or nighttime conditions.

~~If an approaching vehicle is observed driving in the occupied moving work zone lane, the TMA driver should activate the EALs by pushing the switch for a short duration. It is not recommended to leave the lights on very long because continuous or long term use may reduce the effectiveness of the EALs.~~

~~**612.1.3 Protective Vehicle/TMA Expectations for Operations**~~

~~The term "protective vehicle" represents the use of the protective vehicle within operations. The term TMA represents a truck or trailer-mounted attenuator. For the usage of specific protective vehicles within each work space, refer to the (link to TAs)~~

~~The flashing arrow panel and warning lights shall not be active when the Protective Vehicle/TMA is traveling from the home domicile to the staging area/desired lane/work location. Once the Protective Vehicle/TMA has reached the staging area/desired lane/work location, the appropriate operating mode shall be displayed and turned on. If the Protective Vehicle/TMA leaves the staging area/desired lane/work location and travels to another staging area/desired lane/work location, the flashing arrow panel and warning lights shall not be active.~~

**612.~~1.3.1~~1.2 TMA ~~Typical~~ Operations**

**612.~~1.3.1.1~~1.2.1 ~~Stationary Operations~~Construction Projects**

For construction projects, the use of a stationary TMA may be required on the temporary traffic control plans above and beyond the requirements of the MUTCD.~~,~~ If the use of a stationary TMA is required, the stationary TMA ~~but~~ should be included on the temporary traffic control plans, contain the appropriate bid item as well as the applicable JSP for ~~Stationary~~ Truck ~~or Trailer~~ Mounted Attenuator for Stationary Activities.

For ~~contractcontruction~~construction projects, TMAs required for mobile operations, such as striping, are considered incidental per Sec 612.5.

~~For additional guidance for protective vehicle/TMA use within work zones, refer to the typical applications in EPG 616.8 Typical Applications.~~

**612.~~1.3.1.2~~1.2.2 ~~Short Duration and/ Mobile~~MoDOT Operations**

~~For contract projects, TMAs required for mobile operations, such as striping, are considered incidental per Sec 612.5.~~

During MoDOT s~~S~~tationary o~~O~~perations, ~~all protective vehicle/TMA vehicles shall be parked with the transmission in neutral and the parking brake engaged. The vehicle shall maintain a minimum of 150 feet of roll ahead distance to the next vehicle or work activity, be parallel to traffic, and have its wheels aligned with the striping and lane to maintain lane discipline and try to stay within the lane if struck. T~~ it is recommended the operator ~~shall~~ not wait inside or near the ~~protective vehicle/~~TMA vehicle. ~~The employee should proceed to the Work Space to assist other employees and wait for instructions~~.

During MoDOT short duration and ~~/~~mobile operations, ~~protective vehicle/~~TMA operators are allowed to take preventive action by rolling ahead~~,~~ ~~when they perceive possible interaction with an errant vehicle. All TMAs, except TMA#1 are allowed take preventive action. Preventive action includes moving the protective vehicle/TMA forward to lessen impact. If the operator takes preventive action, they should be observant of all crew workers and equipment to maintain a minimum of 150 feet roll-ahead distance and stay in the closed lane. In instances where you do not have the recommended 150 ft. of roll-ahead distance, DO NOT roll forward to lessen the impact and, if possible, engage the parking brake.~~

~~During short duration/mobile operations, if any employees exit their vehicles in the work activityspace, the protective vehicle/TMA#1 operator closest to work activity space shall engage the parking brake~~

~~when exiting their vehicle. The vehicle should maintain a minimum of 150 feet roll ahead distance to the work activityspace, be parallel to traffic, and have its wheels aligned to stay within the lane if struck. If the operator of the protective vehicle/TMA closest to the work activity feels he/she is about to be struck by an oncoming vehicle, the operator may take preventive action if the roll-ahead distance is greater than 150 feet.~~

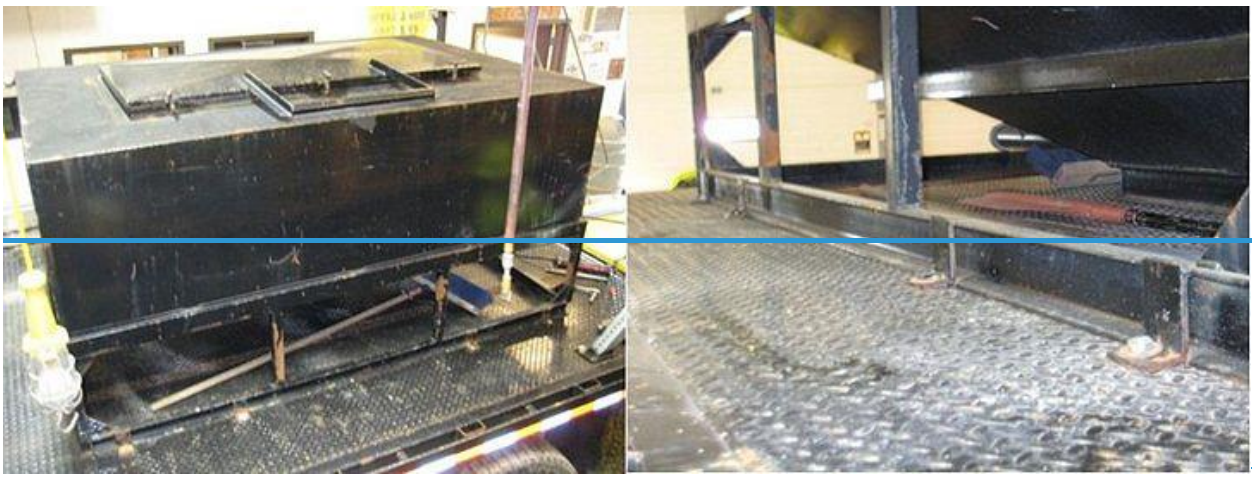
~~For protective vehicle/TMA#2 during short duration/mobile operations, if the operator feels he/she is about to be struck by an oncoming vehicle, the operators may take preventive action to lessen the impact. However, the operator shall maintain a minimum of 150 feet of roll ahead distance to the next protective vehicle/TMA, be parallel to traffic, and have its wheels aligned to stay within the lane if struck.~~

~~For additional guidance for protective vehicle/TMA use within work zones, refer to the typical applications in EPG 616.8 Typical Applications.~~

~~**612.1.4 MoDOT Equipment/Materials Stored in Bed of Protective Vehicle Guidelines**~~

~~Protective vehicles may carry loads or cargo, such as sign posts or tools, in the bed of the protective vehicle. When the protective vehicle is being deployed for protection or has the possibility of deployment prior to getting to the work areaspace, loads or cargo shall be properly secured. Loads or cargo are not allowed to be carried on TMAs.~~

~~Truck beds may be secured to the truck frame to maximize stability during impact. Steel plates and/or containers, secured by approved methods, may be used for ballast or weight to keep the dump bed against the host vehicle frame and may remain in the vehicle while the protective vehicle/TMA is deployed.~~



~~**This bead container is securely fastened to the protective vehicle. The container is bolted through the bed of the truck. The container door is securely latched down.**~~

**612~~.1.5~~1.3 MoDOT ~~Protective Vehicle/~~TMA Operator's Training**

MoDOT operators are required complete MoDOT's Truck-Trailer Mounted Attenuator (TMA) Protective Vehicle training (both classroom and On The Job training) in advance operating a TMA. ~~Training is conducted in two stages:~~

~~Stage 1 – Classroom General Knowledge Training~~

~~Stage 2 – OJT (On the Job) Training and Skills Assessment.~~

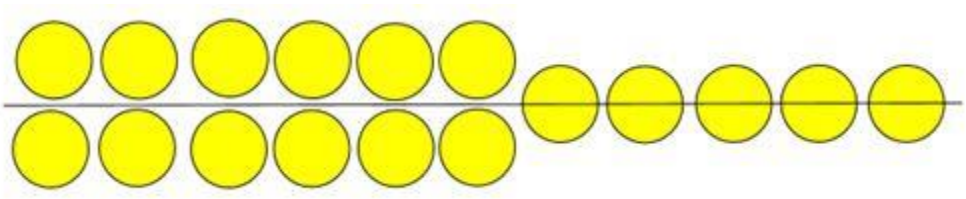
612.2 ~~Sand-Filled~~ Impact Attenuator~~s~~ Array (Sand Barrels)

**Sand Barrels**

An Impact Attenuator Array (Sand Barrels) is most often used to shield fixed objects that cannot be removed or relocated, when posted speeds are greater than 35 mph. These devices are recommended for temporary usage such as in work zones. A benefit/cost analysis is to be conducted before sand barrels are used in a permanent application.

~~This system~~ An Impact Attenuator Array (Sand Barrels) consists of a group of freestanding plastic barrels configured in an array of increasing weights from the impact point toward the object. Such an array transfers the vehicle's momentum to the increasing masses of sand in the barrels and provides a gradual deceleration. Each barrel is designed with a specific weight of sand to absorb the energy of an errant vehicle. The sand barrel array's "footprint" length and width and the number of barrels will change based upon the permanent posted speed limit of the roadway. For the correct setup and array of sand barrel impact attenuators, refer to the manufacturer's recommendations. For more information about manufacturer's recommendations, see End Terminals, Crash Cushions and Barrier Systems.

The pay item will be based on the posted speed limit for the location the sand barrels will be used. Each Impact Attenuator XX mph (Sand Barrel Array) will be paid for per each, as a unit including the number of barrels and weight of sand in each barrel, as required by the manufacturer. ~~for one (1) sand barrel impact attenuator array will include the number of sand barrels the manufacturer requires for the posted speed limit and will be paid for each array.~~ If it is anticipated that the sand barrel array will be relocated during staged construction, the entire array will be relocated and paid for by the pay item Impact Attenuator (Relocation) each time the sand barrel array is relocated. The relocated array should be used in an area with the same posted speed limit, or another pay item will need to be used. An estimate for replacement barrels needs to be included as a separate pay item, typically calculated as one for each sand barrel array. No direct payment is made for the Type 1 object marker on the lead sand barrel in the array.



~~Sand barrels are most often used to shield fixed objects that cannot be removed or relocated. Sand barrels are recommended for temporary usage such as in work zones. A benefit/cost analysis is to be conducted before sand barrels are used in a permanent application.~~

~~An approved sand-filled impact attenuator may be installed on the exposed end of the barrier where the posted speed prior to construction on an existing facility or the anticipated posted speed of a temporary facility is greater than 35 mph.~~

## 612.3 Work Zone Crash Cushion

Work Zone Crash Cushions are used to protect traffic from the blunt end of temporary barrier curb. A crash cushion will be required on the upstream end of barrier curb for divided facilities, and on both ends for all two-way facilities. When space allows, sand barrel impact attenuators are the preferred choice for temporary protection. However, in the event that sand barrels cannot be used (for example, insufficient width), work zone crash cushions may be used instead. Work zone crash cushions provide a narrower option than sand barrels, but still perform the same function. Work zone crash cushions are discussed in EPG 617.1.3.3 Crash Cushion. Applicable pay items are included in the plans.

### 612.~~3~~4 Construction Inspection Guidelines

**Material (for Sec 612.2)** Certifications are to be collected on ~~both the sand and~~ retroreflective sheeting and any other product specified in Sec 1063. ~~used in or on the sand-filled impact attenuators.~~

**Safety Requirements (for Sec 612.3)** The inspector is to request a copy of the manufacturer's certification that states the units comply with the crash test requirements of NCHRP 350 or MASH 2016, Test Level 3. This information is to be kept in the project files.

**Truck~~-~~ Mounted Attenuator (for Sec 612.4.1)** TMAs are to be inspected to make sure they are structurally sound, the frames are not bent and that they appear to be in good working order. In some cases, the contractor may elect to add TMAs when TMAs are not required. Elective TMAs need to be NCHRP 350 or MASH 2016, Test Level 3 compliant and therefore the certification still needs to be collected. ~~Typically, TMAs are only required and paid for under conditions where the contractor is operating without a lane drop set up (cones, channelizers, etc.). TMAs the contractor voluntarily adds to an operation are typically not paid for.~~

**Sand-Filled Impact Attenuator Array (for Sec 612.4.2)** The inspector is to request a copy of the manufacturer's installation instructions for the particular brand of sand-filled impact attenuator the contractor is using. The use of more than one manufacturer's sand barrels in an array is not allowed. When inspecting the sand-filled impact attenuator arrays, make sure that the array is in the location as shown in the temporary traffic control plans, and set up and filled in accordance with the manufacturer's recommendations. All lids are to be on and secured. In order to prevent the sand inside

the barrels from freezing in cold weather, the sand shall have a maximum moisture content and rock salt added, according to Sec 612.4.2.1. ~~MoDOT requires rock salt intermixed with the sand so that any water that gets into the barrels will not freeze and create a safety hazard.~~ The contractor should provide the calculations for moisture content and rock salt content for each barrel, so the specification requirements can be verified. When checking the contents of the barrels, rock salt should be visible in the sand mix, to verify uniform dispersion in the sand. During periods of extended cold weather, the sand should be checked periodically to make sure it has not frozen because the salt content has been exhausted. If this condition is found, the contractor will need to add more salt or replace the sand/salt mixture.

**Work Zone Crash Cushions (for Sec 612.4.3).** The inspector is to request a copy of the manufacturer's installation instructions for the particular brand of crash cushion the contractor is using. When inspecting the work zone crash cushion, make sure that the crash cushion is in the location as shown on the temporary traffic control plans and set up in accordance with the manufacturer's recommendations. If the crash cushion is water-filled, MoDOT requires a mixture content per manufacturer's recommendations so that the crash cushion will not freeze and create a safety hazard. During periods of extended cold weather, the crash cushion(s) should be checked periodically to make sure it has not frozen. If this condition is found, the contractor will need to correct and/or replace the mixture. In the event the work zone crash cushion is damaged and needs to be replaced, it is considered incidental and replaced at no cost to the Commission.

Articles in "612 Impact Attenuators"

This category contains only the following page.

**6**

- ~~612.4 Maintenance Planning Guidelines for Impact Attenuators~~

**This Article is being removed from the EPG**

# ~~612.4 Maintenance Planning Guidelines for Impact Attenuators~~

~~Jump to navigationJump to search~~

~~See Maintenance Planning Guideline for Impact Attenuators.~~

~~Index of all Maintenance Planning Guidelines.~~

~~Category:~~

- ~~612 Impact Attenuators~~

### 616.23.2.5.11 Protective Vehicles

Protective vehicles are used to safeguard the workspace from errant vehicles. In some operations, these devices also serve as platforms for signs and other devices used to warn traffic of upcoming conditions or inform them of needed actions. For increased motorist, driver and worker safety, the protective vehicle may be equipped with a truck-mounted attenuator[AC1]. ~~(See EPG 612.1 Protective Vehicles for additional guidance).~~

MoDOT Protective Vehicles can be any MoDOT fleet vehicle appropriate for the operation.

Positioning of the protective vehicle within the work zone is critical to its effectiveness. The operator will refer to the appropriate typical application for guidance and placement of the protective vehicle.

#### 616.23.2.5.11.1 Equipment/Materials Stored in Bed of Protective Vehicle Guidelines

Protective vehicles may carry loads or cargo, such as sign posts or tools, in the bed of the protective vehicle. When the protective vehicle is being deployed for protection or has the possibility of deployment prior to getting to the work space, loads or cargo shall be properly secured. Loads or cargo are not allowed to be carried on TMAs.

**This Article is being removed from the EPG**

Work Zone Safety and Mobility Policy Resources - Engineering_Policy_Guide (modot.org)

# Work Zone Safety and Mobility Policy Resources

Jump to navigationJump to search

| **Work Zone Safety and Mobility Policy Resources** | |
|---|---|
| EPG 616.22 Advanced Work Zone Training | EPG 616.6.60 Changeable Message Signs (CMS) |
| EPG 910.3 Dynamic Message Signs (DMS) | EPG 616 Temporary Traffic Control Plans |
| *FHWA/MoDOT Oversight Manual* | EPG 616.20 Flagger Training |
| *Manual on Uniform Traffic Control Devices* | Std Plan 616.10 |
| Sec 616 | *MoDOT Work Zone Map* |
| EPG 616.19 Quality Standards for Temporary Traffic Control Devices | Temporary Traffic Control Inspection Worksheet |
| EPG 616.23 Traffic Control for Field Operations | *Transportation Management Plan Strategy Matrix* [1] |
| EPG 612.1 Truck-Mounted Attenuators | *Work Zone Inspection Form* |
| Work Zone User Training, Web Version | Work Zone Technician Training |
| [1] After clicking the matrix located on the website page, the file must be saved in the user's computer before work can be done in it. | |
| **Additional FHWA online resources include:** | |
| *Work Zone Mobility and Safety Program* | *Final Rule on Work Zone Safety and Mobility* |
| *Work Zone Mobility and Safety Self-Assessment Guide* | *Road Safety Audits* |
| *Full Road Closure and Lane Closure for Work Zone Operations* | *Innovative Contracting Guidance* |
| *ITS in Work Zones* | *NHI Work Zone Training Courses* |

*Fonts/Picture Numbers/Size- are subject to final formatting

# 616.19 Quality Standards for Temporary Traffic Control Devices

Temporary traffic control devices (TTCDs) are an essential part of highway work zones. ~~Even though workers and flaggers are not devices, they will be described in this article because of their relationship with work zones.~~ TTCDs warn motorists of hazards, advise them of the proper path through the work area, delineate areas where they may not operate and separate motorists from workers and opposing traffic.

There are many factors that ensure the success of these functions; the placement and condition of each TTCD are two important factors. TTCDs that are worn, damaged or improperly installed will significantly lower the overall quality of a work zone. Clean, legible, properly installed TTCDs will command the respect of ~~road users~~the traveling public.

These quality standards are intended as a resource to determine if TTCDs are meeting current traffic needs in terms of legibility, visibility and other safety and mobility requirements for TTCDs (e.g., impact attenuators, truck-mounted attenuators, signs, channelizers, barricades, changeable message signs, flashing arrow panels, work zone traffic signals, ~~lighting units,~~ temporary pavement marking, temporary traffic barrier, etc.) deployed on the state highway system. Effective application of these quality standards will benefit everyone that works in or navigates through work zones on the state highway system.

**Inspection Worksheet**

Temporary Traffic Control Inspection Worksheet

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**Quality Standards for Temporary Traffic Control Devices**

This Work Zone flyer shows the top deficient Temporary Traffic Control Devices.

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**Easily Printable Version of Quality Standards for Temporary Traffic Control Devices**

~~EPG 616.19 Quality Standards for Temporary Traffic Control Devices presents the very latest information, but this pdf file may be helpful for those wanting to easily print this info as it existed in 2013.~~

## 616.19.1 Quality Requirements

TTCDs shall be installed and maintained in an acceptable condition. Unless specified otherwise, this requirement does not mandate the use of new devices, but it does necessitate the use of functional devices. Unacceptable devices shall be replaced or corrected in accordance with the contract documents or in the absence of a contract (e.g., permit projects) as directed by MoDOT's representative.

When reviewing work zones, the MoDOT ~~Temporary Traffic Control~~ Work Zone Inspection ~~Worksheet~~ Checklist is a valuable tool for determining the safety and mobility performance of all work zones including federal and state funded contracts, state maintenance, and permit projects ~~(as shown at the end of the article)~~.

~~The MoDOT Temporary Traffic Control Inspection Worksheet rating system is based on the following letter grade system:~~

~~**A** – Above and beyond the standards and specifications of the project.~~
~~**B** – Meeting the standards and specifications of the project.~~
~~**C** – A couple of deficiencies meeting the Category 3 severity level of Sec 616 (http://www.modot.org/business/standards_and_specs/SpecbookEPG.pdf#page=9).~~
~~**D** – Several deficiencies meeting the Category 3 severity level of Sec 616 or a couple of deficiencies meeting the Category 2 severity level of Sec 616.~~
~~**F** – Several deficiencies meeting the Category 2 severity level of Sec 616 or one or more deficiencies meeting the Category 1 severity level of Sec 616.~~

~~Category severity levels are as follows:~~

~~**Category 1** – Presents an immediate safety issue for the traveling public or workers and needs to be addressed immediately.~~

~~**Category 2** – The situation doesn't pose an immediate safety issue for either the public or the workers that can impact the proper functioning of the work zone.~~

~~**Category 3** – The situation doesn't impact the functioning of the work zone but is more of a maintenance or aesthetic issue.~~

~~When inspecting a work zone and a Category 1 severity level is noted, remain at site until the appropriate personnel has been contacted and advised of the deficiency. For Categories 2 and 3, contact the appropriate personnel as soon as possible. The district Work Zone Coordinator is a valuable resource and the primary point of contact for questions and concerns.~~

Document all deficiencies on the ~~worksheet~~ checklist along with any corrective action(s) taken and/or the time/date that appropriate personnel was contacted to initiate the corrective action(s).

The work zone should be re-inspected to ensure that all deficiencies have been corrected.

## 616.19.2 Quality Standards

### 616.19.2.1 General

All TTCDs shall be:

- In conformance with the requirements of the MUTCD and MoDOT Standards.
- Installed and maintained at locations and in orientations that maximize safety and minimize disruption to traffic flow.
- Aligned with the road user's line of sight.

- Positioned in a manner not to obstruct other traffic control devices.
- Free of dents, holes, deformations, abrasions, tears, marks, stains, residues, fading or other deficiencies that adversely affects the operational performance including the crashworthiness of a device.
- Properly covered, turned, stowed, or removed when not in use.
- Visible during daytime and nighttime operations.

If TTCDs such as signs, channelizers, etc. have damage resulting in 25% or more deterioration of the lettering, border, or symbol, the device shall be replaced in an agreed upon time with the engineer. Furthermore, if the device is experiencing a reduction in retroreflectivity by 25% or more due to residue, fading, or damage, the device shall be replaced in an agreed upon time with the engineer.

### 616.19.2.2 ~~Signs~~Advance Warning Area

## 616.19.2.2.1 Sign Placement and Installation (moved from 616.19.2.2.6 to flow with when they first appear in work zone)

Sign Height: (updated pictures)

**Acceptable Examples**


The post mounted sign shown in Picture 1 is mounted 5-foot ~~ft.~~ in height~~high~~ from the edge of the roadway to the bottom of the sign as required for a rural location. For urban locations, post mounted signs should be 7 ~~ft.~~-feet as shown in **Picture 2**. For short term projects temporary signs, as shown in **Picture 3**, may have a minimum height of one foot. Additional information on sign installation and heights see Standard (Std.) Plan 616.10.

**Acceptable Example**


When used, speed limit (regulatory) signs shall be installed at a 5 ~~ft.~~ -foot (rural area) or a 7 ~~ft.~~ -foot (urban area) mounting height as shown in **Picture 4**. Information on the mounting height of the signs is in Std. Plan 616.10. The WORK ZONE PLAQUE (Go20-5Ap) shall be 2-foot height as shown in 616.6.12 Work Zone and Higher Fines Signs and Plaques (MUTCD 6F12).

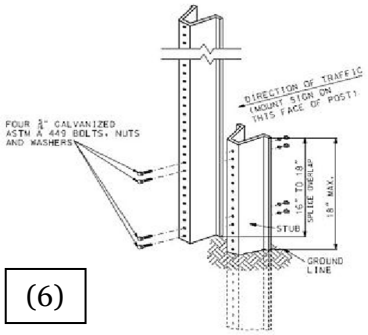
**Unacceptable Examples**


(removed picture 6- outdated)

The mounting height~~s~~ and the WORK ZONE plaque (GO20-5aP) of the sign~~s~~ in **Pictures 5** ~~and 6 are~~ is not compliant with MoDOT/MUTCD standards. ~~The work zone plaque will be 2 ft. high as shown in EPG 616.6.12 Work Zone and Higher Fines Signs and Plaques .~~

**Lateral Sign Location:** Sign locations should be located 6-12 ~~ft.~~ feet from the edge of the paved travel lane or shoulder as shown in Std. Plan 616.10 . Before installing signs, the project site should be reviewed to agree on the best location for signs. When stubs are not driven deep enough into the ground a sign may lean or fall after a period of time. Due to terrain slopes, curves, shoulder widths, duration of projects, signs may deviate from recommended placement to achieve a plumb position, be sure to document. ~~Before installing signs, the project site should be reviewed to agree on the best location for signs.~~

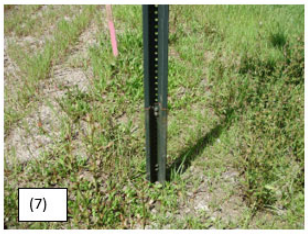
**Post Installations:**




(6)

**Picture 6** illustrates the proper installation for posts. The complete U-channel Post details are located in Std. Plan 616.10 ~~on Sheet 2~~.

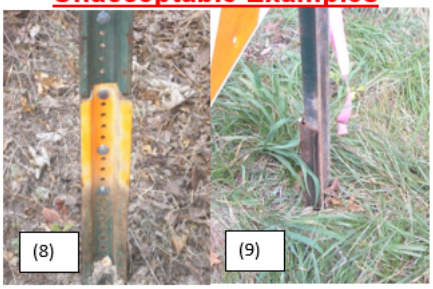
**Acceptable Example (separate acceptable/unacceptable examples)**



(7)

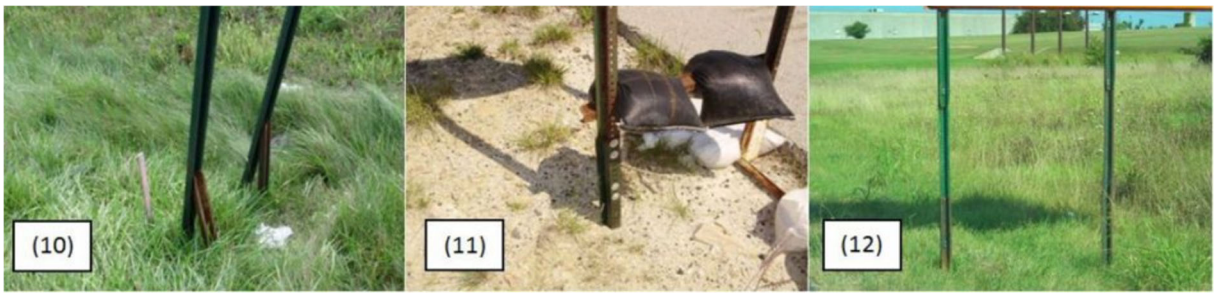
**Picture 7** is an example of a correct U-channel post splice, which shows the four bolts in the proper location, correct stub height and splice overlap.
Note: The bolts can be installed in either direction.
Note: Missouri One-Call should always be notified prior to installing any ~~sign post~~signpost into the ground.

**Unacceptable Examples**



(8) (9)

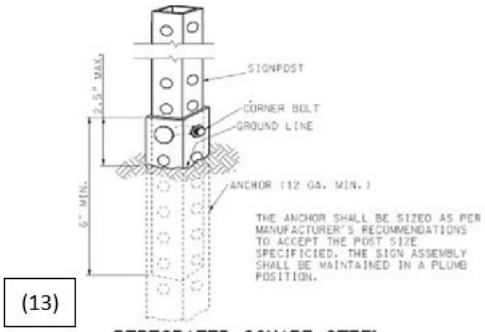
The stub height and splice overlap in **Picture 8** is correct, but the 4-bolts are not in the proper locations. Picture 9 shows inadequate stub height and overlap and the signpost is not on the correct side of the stub.



(10) (11) (12)

Unacceptable Examples

The installations in **Pictures 10-12** are unacceptable. **Picture 10** shows an installation of only 1 bolt per ~~sign post~~signpost leg. **Picture 11** shows an installation of one post mounted leg and one skid mounted leg. Picture 12 shows two splices when only one splice is allowed.




PERFORATED SQUARE STEEL TUBE POST DETAIL

Picture 13 is a Perforated Square Steel Tube Post (PSST) with more details ~~are~~ located in Std. Plan 616.1~~9 on Sheet 20~~.

**(separate acceptable and unacceptable examples)**


**Pictures 1~~3~~4 and 1~~4~~5** shows proper installation of a PSST post. The PSST post does not have to use the corner bolt but can be bolted either with one or two straight bolts. However, the corner bolt minimizes movement of the post within the tubes. ~~Picture 15 shows a stub higher than the 2.5" maximum and the bolt should be bolted through the two posts.~~ Note: Missouri One-Call should always be notified prior to installing any ~~sign post~~signpost into the ground.

**Unacceptable Example**


**Picture 16** shows a stub higher than the 2-inches maximum and the bolt should be bolted through the two posts.

~~Picture 16 shows a crashworthy self-driving sign stand. Note: Missouri One-Call should always be notified prior to installing any sign post into the ground.~~

## 616.19.2.2.2 Sign Flag and AWRS Quality

Acceptable Examples


The signs ~~and flags~~ in **Pictures 1, 2 and 3** are considered in good quality. ~~For enhanced visibility~~ Supplemental devices such as flags and/or a cone may be placed next to a sign. **Picture 2** is an example of the proper placement of a FLAGGER (WO20-7) sign, with the optional flags, in advance~~d~~ of the hill v~~s.~~ersus after the hill. In urban areas with barrier walls and narrow shoulders, a truncated sign may be used as shown in **Picture 3**.

**NOTE:** TTCDs may be highly visible during the day but may not be at night due to inadequate retroreflectivity. MoDOT and Contractor representatives should drive through the work zone at night to check nighttime visibility.

**Unacceptable Examples**

Unacceptable Examples


~~The above signs (4, 5, 6 and 7)~~**Pictures 4-7** are in unacceptable condition. Dirty or damaged signs should be cleaned, repaired, or replaced before being installed. When cleaning, follow manufacturer's recommendations, so that the daytime and nighttime visibility of the sign is not adversely impacted. The MEN WORKING sign (**Picture 8**) should be replaced with worker symbol sign or WORKERS sign (WO-21-1 or 1a) to meet current standards. **Picture 9** shows unacceptable flags, ~~,~~ if used, ~~D~~deteriorated flags should be replaced.

(updated pictures)


~~**Signs 10 and 12**~~ **Pictures 10 - 13** are examples of ~~acceptable nighttime visibility and signs 11 and 13 are examples of~~ unacceptable nighttime visibility. Proper storing, ~~transporting~~transporting, and covering signs is crucial to minimizing deficiencies~~can lengthen the life of a sign~~. ~~Rigid signs should be stored and transported vertically without rubbing the sign face.~~

Acceptable Examples (updated pictures)


Advance Warning Rail System (AWRS) is required on the first advance warning sign (Road/Bridge Work Ahead) on long-term stationary projects. The barricade stripes should slope downward toward the roadway as shown above. Pictures 14 ~~and 15 are~~ is an example~~s~~ of acceptable AWRS installations. When a Type 3

Barricade is used with a sign as shown **Picture 1~~6~~5**, the barricade should be located between 7 to 10 ft~~.~~eet from the sign (to be crashworthy). Either a 4 ~~ft.~~-foot or 8 ~~ft.~~ -foot barricade may be used. A 4 ft~~.~~oot AWRS on single post is acceptable as shown in **Picture ~~17~~ 16** provided the ~~sign post~~signpost has been sized to accommodate the added weight and square footage of the AWRS. ~~AWRS with vertical legs are acceptable if bolted to the sign post legs as shown in picture 18.~~

## 616.19.2.2.3 Proper Sign Color

**(updated pictures)**

Sign colors are reserved for specific applications. Orange is reserved for temporary traffic control, pink for incident management, yellow for warning, and red/black/white for regulatory signs.

**(separate acceptable and unacceptable)**

**Acceptable Example**


Fluorescent orange signs as shown on the right in Picture 1 are required for MoDOT contract and maintenance projects. Permit projects may use engineering grade sheeting as shown on the left side of Picture 1 provided they meet MUTCD reflectivity requirements.

**Unacceptable Examples**


The UTILITY WORK AHEAD (WO21-7) and the LANE CLOSED AHEAD (WO20-5) signs in **Pictures 2 and 3** should be orange not pink or yellow. ~~The speed limit sign in picture 4 is correct color for a regulatory sign. The WORK ZONE plaque is required for speed limit signs within a work zone if it changes the posted speed limit. Fluorescent orange signs as shown on the right in Picture 1 are required for MoDOT contract and maintenance projects. Permit projects may use engineering grade sheeting as shown on the left side of Picture 1 provided they meet MUTCD reflectivity requirements.~~ Note: Using tape on a sign can destroy the retroreflectivity of the sign as shown in **Picture 3**.

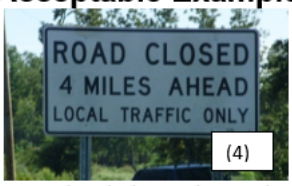
## 616.19.2.2.4 Information From the Signs


Unacceptable Examples

**Pictures 1 ~~thru~~ 3** are examples of ~~TTCDs~~ signs that are visually obstructed or providing conflicting information. ~~The TTCD in~~ **Picture 1** should be moved upstream from the permanent curve warning sign with written documentation as to why the sign was moved. The advance warning sign in **Picture 2** should be relocated upstream of the tree or the tree should be trimmed (if within MoDOT ROW) to provide the required visibility. **Picture 3** shows detour signs that are providing two detour options for the same route. To reduce ~~motorist~~ road user confusion, it is best to provide only one detour option.

(separate Acceptable and Unacceptable signs)

**Acceptable Example**




**Picture 4** is an acceptable use of ~~T~~the ROAD WORK NEXT XX MILES (GO20-1), as it uses ~~signs have~~ whole numbers only. Do not use decimals ~~or part~~ of a mile.

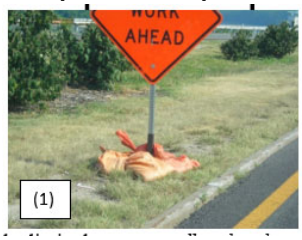
**Unacceptable Examples**


~~In Picture 4, the ROAD WORK NEXT XX MILE sign may look like 31 miles instead of 3.1 depending on speed of the motorist. For ROAD CLOSED XX MILES AHEAD signs, partial miles, for example 0.5 (Picture 5) or 1/2 mile may be used but standard practice is to round miles to a whole number of miles or within 1 mile or just state AHEAD.~~ Pictures 5 and 6 are unacceptable signs because the specified miles are not listed as whole numbers.

# 616.19.2.2.5 Ballasting of Signs

**(separate acceptable/unacceptable examples)**

**Acceptable Example**




For portable signs, ballasting should be limited to one ~~*sand bag*~~*sandbag* ~~*height*~~ *layer* on the sign legs as shown in **Picture 1**.

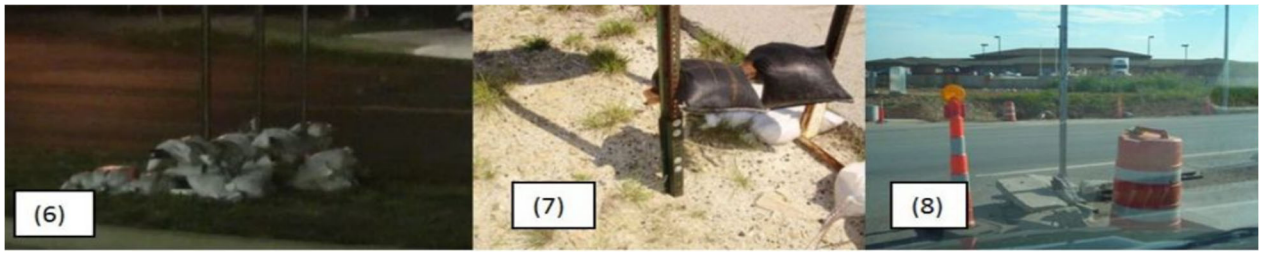
**Unacceptable Examples**


The use of channelizer rings as shown in **Pictures 2 and 3** are unacceptable as ~~it may make the installation not crashworthy~~the crashworthiness has not been verified.

## Acceptable Examples


For skid mounted signs, ballasting should be limited to one ~~sand bag~~*sandbag* ~~height~~ *layer* on the sign legs as shown in **Pictures 4 and 5. Picture 5** shows an acceptable use of ballasting for a skid mounted sign. The crossbar (**Picture 5**) should be no higher than 12 inches~~.~~ (one sandbag over the crossbar is acceptable).

## Unacceptable Examples




**Picture 6** shows a large mound of sandbags, which if hit could present a ramping situation for vehicles. **Picture 7** has two sandbags on the crossbar which is unacceptable a n d u t i l i z i e s ~~because of~~ two t y p e s o f ~~different~~ ~~sign posts~~ mounting styles ~~and two sandbags on the cross rail~~. In **Picture 8,** concrete is being used to ballast the sign, which is not crashworthy and is **unacceptable**.

# 616.19.2.2.6 Additional Sign Examples

Unacceptable Examples

**Picture 1** shows a cross ~~brace~~bar above the 18~~-~~ in~~.~~ch maximum height without ~~sand bag~~sandbag or 12 ~~in.~~ ~~-~~ich maximum height with sandbag. **Picture 2** shows a skid


mounted sign stand laying on the ground attached to the sign post. The skid mount should be removed from the sign post and placed flat on the ground. As shown, this sign stand is not crashworthy. **Picture 3** shows a sign laying in the street. This sign should be placed in a better location. **Picture 4** shows two crashworthy signs that have been placed closer than the recommended 7-10 ~~ft.~~ feet spacing making them not crashworthy. The 7-10 ~~ft.~~feet spacing allows the signs to act independently of each other to meet crashworthy criteria.


**Picture 5** is an example of a STOP (R1-1) sign not having a full face visible to the ~~traveling public~~road user. The sign in **Picture 6** is leaning and should be ~~straightened to be perpendicular~~ plumb. ~~When stubs are not driven deep enough into the ground a sign may lean or fall after a period of time.~~ The sign in **Picture 7** could be moved upstream or downstream to achieve a ~~more perpendicular~~plumb position. Be sure to document the location change, such as, “After reviewing the sign in the original position, the sign was moved 100 ~~ft.~~ -feet upstream to be ~~more level~~achieve a plumb position”. ~~There are times due to terrain that a~~

~~sign may not be completely level, but every effort should be made to install signs as close to perpendicular as possible.~~

Unacceptable Examples

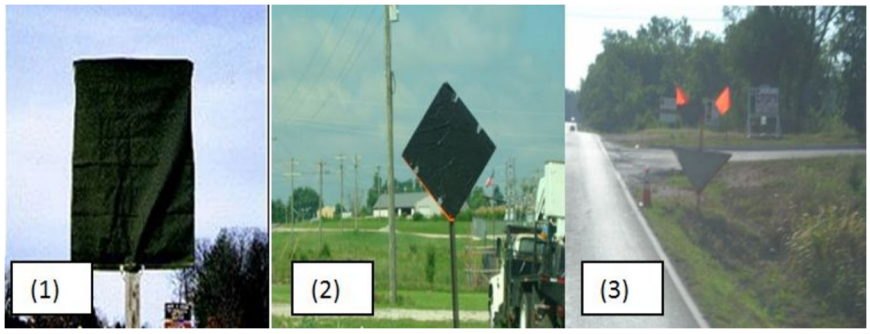

Sign placement in urban areas can impede ~~pedestrian~~ non-motorized travel as shown in **Picture 8**. Accommodations should be made for all modes of travel including non-motorized traffic such as, pedestrians and bicyclists. The ~~sign post~~signpost in **Picture 9** should have only one sign~~, but a speed advisory plaque is allowed as shown in Std. Plan 616.10~~. A permanently posted SPEED LIMIT (R2-1) sign, as shown in **Picture 10**, should not be removed. If the posted speed limit is lowered, the proper procedure is to cover the sign as described in 616.19.2.2.7 Sign Coverings. ~~Since the posted speed limit is laying down and the work zone speed limit was not in place, by state law the speed limit for this road's functional classification could be higher than the posted speed limit. Placing the permanent sign on the ground could also reduce the life of the sign and/or void the manufacturer's warranty.~~

Unacceptable Examples


**Picture 11** shows an example of two work zones placed inside each other. Proper coordination should be one of the highest considerations when work zones overlap each other. **Picture 12** shows the signal head upside down. ~~Picture 13 shows a new detour sign design on the right.~~

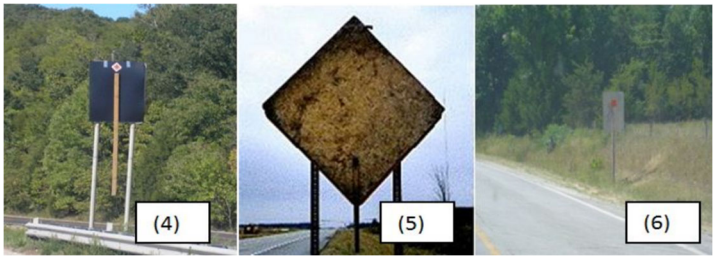
# 616.19.2.2.7 Sign Coverings

Acceptable Examples




**Pictures 1 ~~thru~~ 3** show examples of signs properly covered with plastic sign cover, plastic taped securely to the sign without direct contact with the sign face and a roll-up sign folded down. Materials used should not allow the sign face to "bleed through" during daytime or nighttime use. **Pictures 1 and 2** adequately cover the face of the sign.

Acceptable Examples




**Pictures 4 - ~~thru~~ 6** are examples of acceptable materials to cover signs. Materials range from rubber that is used for mud flaps~~, lightweight plywood,~~ or a matching s i z e d sign cover. The sign covers should be adequately secured to the host sign assembly and sized to match the sign to completely cover the face. The cover should be constructed with non-metallic (such as wooden, plastic, etc.) handles and spacers to keep the sign covers from damaging the sign face.

Unacceptable Examples


The sign cover in **Picture 7** is not securely fastened and does not have a ~~wooden~~ non-metallic handle. **Picture 8** shows the sign cover not matching the shape of the host sign, which could provide conflicting information to ~~motorists~~the road user. **Picture 9** shows duct tape covering part of the sign wording, which can damage the sign retroreflectivity. **Picture 10** shows an example of unacceptable use of plastic taped to the sign. The plastic is thin which illustrates the "bleed through" of the message and it is falling ~~coming~~ off and the sign ~~message can be read~~. ~~The plastic is so thin that the words can be seen through the plastic.~~

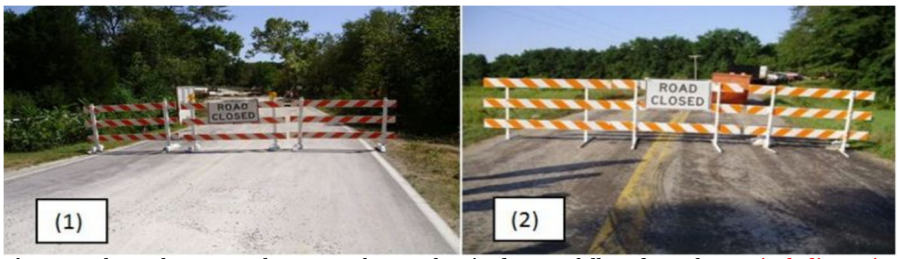
## ~~616.19.2.2.8 Sign Innovations~~

~~**Pictures 1 and 2** are examples of an innovative solution to use roll-up signs on the emergency reference markers for short duration work. Remember modifications to TTCDs may cause crashworthy concerns, requiring study and/or crash testing. Always check first before installing.~~

(Channelizing Devices moved to 616.19.2.3.3)

## ~~616.19.2.2.9~~616.19.2.2.8 Barricades

Acceptable Examples




**Picture 1** shows the proper placement of Type 3 barricades on a full roadway closure, including stripe direction. The barricade installation also provides an adequate buffer space to the work area. At some locations, barricades may have to be located at the bridge ends or work area due to side roads. **Picture 2** shows equipment behind the barricades ~~with as much buffer as could be provided due to an entrance located just upstream of the barricades~~.

Unacceptable Examples

**Picture 3** shows a barricade installation located after the private entrance and before the bridge end, not enough buffer space. ~~Notice how close the equipment is to the barricade, which creates a potential safety issue for workers and motorists should a vehicle crash through the barricade. Sites should be reviewed for the best location to store equipment/materials within the work area. For this example, the opposite end of the bridge had ample room to store equipment and worker vehicles.~~ In **Picture 4**, ~~shows acceptable sheeting quality for nighttime use but~~ notice the left barricade stripes are angling to the left instead of to the right. ~~On full roadway closure, the stripes should slope into the Road Closed sign as shown in **Pictures 1 and 2**.~~


**Picture 5** shows ~~Road Closed~~Type 3 barricades that were moved to let vehicles into the work ~~area~~zone. ~~Except for continuous deliveries of materials, the barricades should be opened and re-closed when the work vehicles enter or leave the work zone.~~ **Picture 6** shows a haul truck entering a work zone and leaving the barricades open which~~, with the barricades placed in front of the road closed sign. This~~ could allow the ~~traveling public~~road user to follow the haul truck. **Picture 7** shows the barricades staggered to allow haul trucks in and out of the work zone which is not permitted~~and the hauling was continuous (one truck every 5 to 10 minutes). This was allowed by the inspector of the project, but once the hauling was completed the road was closed with the barricades as shown in **Pictures 1 and 2**. The ability to stagger the barricades for hauling/delivery purposes should be authorized by the inspector on construction projects or superintendent on maintenance operations.~~


**Pictures 8 and 9** show trucks parked in front of barricades, obstructing them from oncoming traffic. Note: Equipment or vehicles should not be parked in front of barricades they should be moved to an appropriate location (i.e., behind the barricades).

(separate acceptable and unacceptable examples)

**Acceptable Examples**


**Picture 10** shows a ~~staggered~~ soft closure which is intended to allow~~s the traveling public to decide if they want to go down the road before they get to~~local traffic only~~to get to the desired desination before~~ the full closure. ~~The staggered closure in **Picture 11** allows any traffic to turn around at the last entrance (lower right) in advance of the full closure.~~ One barricade and ROAD CLOSED (R11-2) sign~~s~~ as shown in **Picture 1~~2~~1** can be used to inform the ~~traveling public~~road user of ~~road~~ closures, which when used should be located on the shoulder.

**Unacceptable Examples**


The barricade in **Picture 1~~3~~2** is directing the ~~traveling public~~road user into the opposite lane and not directing them back into the proper lane of travel with another barricade in the opposite lane. A single " R~~oad Closed~~OAD CLOSED XX M~~iles Ahead~~ILES AHEAD" (R11-3a) sign is allowed without barricades. **Note:** A full barricade closure is required at the work area.

**Unacceptable Example**


The ballasting in **Pictures 1~~4~~3 ~~thru~~ - 1~~7~~6** show unacceptable applications. Tires should not be used as ballast. Sandbags are allowed ~~as long as~~if they are not stacked on each other (i.e., ~~one bag level high~~a single layer to meet crashworthiness). As shown in Pictures 13~~4 thru~~ - 15~~6~~, the signs may be placed behind the Type 3 barricades. To be crashworthy, the sign and barricade should be separated by 7 to 10 ~~t.~~feet from each other so each device can act independently if struck by a vehicle. **Picture 1~~7~~6** shows old barrel rings around the legs of the barricades. If rings are used, only one is allowed per leg.

Unacceptable Examples


The road closures in **Pictures 1~~7~~8 ~~thru~~ - ~~20~~ 19**are unacceptable installations, the Type 3 barricades should cover the full roadway width to meet the requirements for a full road closure. The damaged rail sheeting on the barricades in **Picture 19~~20~~** is unacceptable.

## ~~616.19.2.2.10~~616.19.2.2.9 Changeable Message Sign /Flashing Arrow Panels /Traffic Signals (moved up)

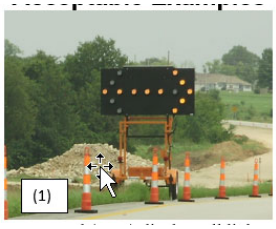
~~Trailer mounted devices such as changeable message signs (CMS), flashing arrow panels (FAP), portable traffic signals and work area lighting are considered FHWA Category 4 devices for both NCHRP 350 and MASH 2016 (see below).~~

~~**FHWA Explanation of Category 4**~~

~~Category 4 devices are devices which have proven to have significant value in the work zone by contributing to safer traffic operation though these devices may cause great harm to occupants of impacting vehicles. We believe that, as currently configured and deployed, these devices provide a net benefit to motorists. Substantial crash experience to date shows that crashes with these devices are rare. They have been identified by FHWA as portable, usually trailer-mounted, devices such as area lighting supports, flashing arrow panels, temporary traffic signals, and changeable message signs which are often used in or adjacent to the traveled way.~~

(separated acceptable/unacceptable- update pictures)

## Acceptable Examples




**Picture 1** shows the correct flashing arrow panel (FAP) display, all lights are working and have the proper intensity. Listed below are items that would make the FAP installation unacceptable:

- More than one lamp is out in stem.
- One or more lamps out in the arrowhead(s) when in the arrow (single- or double-headed).
- One or more lamps out when in the caution (four corners) modes.
- Not appropriate light intensity for work zone conditions, as described in 616.6.61 Arrow Boards.

## Unacceptable Examples


**Picture 2** shows one lamp out in the ~~arrow head~~arrowh e a d which is unacceptable. **Picture 3** shows a truck blocking a FAP which is unacceptable. ~~Below are items that would make the FAP installation unacceptable.~~

~~More than one lamp, of those to be energized, out in stem and one or more lamps out in the arrow head(s) when in the arrow (single- or double- headed) and one or more lamps out when in the caution (four corners) modes.~~

~~Not appropriately dimmed at night~~

Acceptable Examples


The Changeable Message Sign (CMS) messages in **Pictures 1, 2 and 3** are acceptable. The messages provide information that static signs cannot provide to the ~~traveling public~~road user. The CMS are placed further upstream of the work zone or at strategic locations to provide information about the upcoming work zone to the ~~traveling public~~road user. The channelizer placement in **Picture 1, 2 and 3** shows the correct number of channelizers (5) and the correct placement (~~approximate~~ 100 f~~t.~~oot taper). Channelizers are not required if the CMS is more than 15 -f~~t.~~eet from the edge of shoulder (edge of the roadway if there is no shoulder), beyond ditch line, or behind curb or ~~physical~~ temporary traffic barrier (TTB) (see Std. Plan 616.10 for further details). **Picture 4** shows a Dynamic Message Sign (DMS) providing information of a work zone. Appropriate messages can be found in EPG 910.3.2.10 Acceptable Abbrevations.

~~Messages on CMS boards should consist of no more than two phases and each phase should consist of no more than three lines of text. The maximum line of text should be no more than 8 characters.~~

Unacceptable Examples


**Pictures 5, 6 and 7** are examples of CMS that are unacceptable due to the lights being either ~~too dim~~ the incorrect intensity or out, as they are not providing a clear and concise message to the ~~traveling public~~road user.


**Pictures 8 and 9** show active CMS in nighttime operations. **Picture 8**, the message is ~~too dim~~the incorrect intensity and not visible. **Picture 9**, message is ~~too bright~~incorrect insensity that makes it too bright and creates a glare. ~~The CMS should be appropriately dimmed so the lights are not too bright for the traveling public.~~


**Picture 10** shows a CMS where the lights are out or turned off. If the lights are not working, the CMS is unacceptable. If the CMS is not being used it should be turned off and rotated away from traffic as shown in **Picture 11** or removed from the project. ~~If the CMS is used when lane drops are used every day to 3-4 days, then rotating the sign would be appropriate. If the CMS will not be needed for a week or more, then removal may be appropriate until it is needed again.~~ Note: The taper length should be ~~.~~100 f~~t.~~eet long with five channelizers.


**Picture 12** shows a permanent sign blocking the CMS. In **Picture 13**, the truck should not be placed in front of the CMS board. For **Picture 13**, the speed limit should not be on a CM. ~~message is just a reminder of the speed limit. A temporary sign should be used instead, and the CMS removed. Actual enforcement of the speed limit requires a regulatory sign.~~

### 616.19.2.3 Transition Area

## ~~616.19.2.3.1~~ ~~Worker Apparel~~

~~MoDOT Personnel: The proper apparel for working and flagging situations is located in the following sections of the Risk and Benefits Management Manual:~~

- ~~Section 100 Head and Eye/Face Protection Policy~~
- ~~Section 105 Safety Footwear Policy~~
- ~~Section 106 Class II and III Safety Apparel~~
- ~~Section 107 Prescription Safety Eyewear~~

~~**Contractor and Permit Personnel:** The proper apparel for working and flagging situations is in the following sections and articles:~~

- ~~Specification Section 616 Temporary Traffic Control~~
- ~~EPG 616.18 Construction Inspection Guidelines for 616~~
- ~~Contractor Safety Plan~~

~~Pictures 1 and 2 show the required MoDOT ANSI/ISEA Class 2 shirt or vest. Picture 3 shows a Class 3 jacket. Picture 4 shows Class E pants. During daytime operations, MoDOT personnel shall wear a minimum of Class 2 safety vest or shirt. During nighttime operations, MoDOT personnel shall wear a minimum of Class 3 safety apparel (Class 2 or 3 top and Class E pants). Pictures 1 and 3 show the required head, eye, and foot wear.~~

## ~~616.19.2.3.2~~616.19.2.3.1 (616.19.2.3.1.1)

~~616.19.2.3.1 Flagging Operations~~

~~**Acceptable Examples**~~

~~Picture 1 shows the flagger on the right side of the road stopping traffic and maintaining good eye contact with the traveling public. Once the flagger stops the first vehicle, the flagger proceeds to the middle of road where the flagger is visible to oncoming traffic as shown in Picture 2. Flaggers should be aware of their surroundings. When it is time to release the vehicles (Picture 3), the flagger will return to the edge of the roadway or the shoulder and provide direction to the traveling public. Flaggers should be located at least 100 ft. from any equipment or vehicles and have an escape route.~~

~~**Unacceptable Examples**~~

~~The flagger in Picture 4 does not have an escape route due to his location to the truck. The STOP/SLOW paddle should not be in a channelizer, but move with the person flagging the operation. The public should be separated from the work areas. The flagger in Picture 5 is not fully in control of his location and has no escape route. Picture 6 shows a flagger without an escape route and not following proper procedures.~~

~~**Unacceptable Examples**~~

~~Flaggers should stay at their station until either relieved or can be safely transferred to another location, the flagger should not have their back turned to oncoming traffic (picture 7). Picture 8 has too many vehicles around the flagger; the flagger is located on the left of the dump truck. A flagger should not be located in the middle of the sign package but downstream of the flagger symbol sign (Picture 9).~~

~~A pilot vehicle is an effective option that can be used to guide motorists safely through work zones. The pilot vehicle driver should be familiar with the project and should control vehicle speeds through the project. **Picture 12** shows a pilot vehicle with the appropriate sign on the rear of the vehicle which is highly visible to oncoming traffic. The PILOT CAR IN USE WAIT & FOLLOW sign (**Picture 13**) should be used at state intersections and may be used on other routes as directed by the engineer. The sign should be removed or laid down when it is no longer applicable. Note: Flags are optional on these signs.~~

~~**Pictures 14 thru 16** are examples of portable traffic signals, automated flagger assistance devices, and portable signal flagging devices.~~

### ~~616.19.2.3.2 Tapers/Transition Areas/Lane Widths/Crossovers~~

~~**Acceptable Example**~~

~~**Picture 1** shows a proper crossover. The opposing lanes are completely closed with Type 3 barricades.~~

~~Unacceptable Example~~

~~**Picture 2** where the lanes are not completely closed with Type 3 barricades.~~

### ~~616.19.2.3.3~~616.19.2.3.1 Channelizing Devices (moved)

# Acceptable Examples

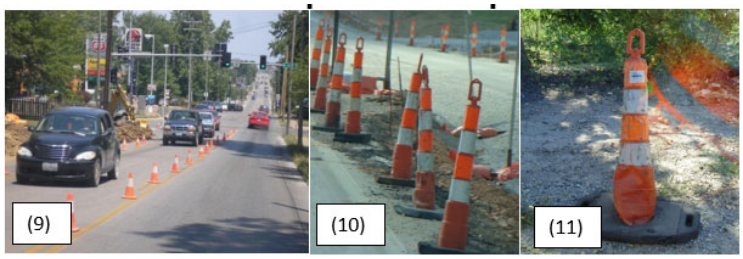

Trim-line ~~channelizers~~ shown in **Pictures 1 and 2** are the most commonly used work zone channelizer. **Picture 3** shows trim-like channelizers with sequential lights on a nighttime interstate project. **Picture 4** shows a drum-like channelizer. Trim-line and drum-like channelizers are commonly ballasted with weights called "rings", which prevent the channelizers from being blown over ~~by vehicles~~. ~~Stacking of ballasts may be considered if it meets manufacturer's recommendations for crashworthiness.~~


The direction indicator barricades (DIB) in **Picture 5** are commonly used in the merge tapers, but the DIBs in **Picture 6** with the panels on the drum-like channelizer are also acceptable. **Picture 7** shows DIBs during a nighttime work zone.

(separate acceptable and unacceptable examples)


**Picture 8** shows tubular markers separating opposing traffic.

# Unacceptable Examples




**Picture 9** shows 28 ~~in.~~ -inch cones being used for daytime projects on a minor roadway. ~~Contract and maintenance operations are allowed to use the 28 in. cones on minor roadways and during daytime hours. Permit operations are allowed to use cones based on MUTCD standards.~~ **Picture 10** shows trim-line channelizers that may have limited nighttime visibility. **Picture 11** shows a damaged trim-line that is in unacceptable condition.

## 616.19.2.4 Activitiy Area

### 616.19.2.4.1 Temporary Traffic Barriers (moved up)

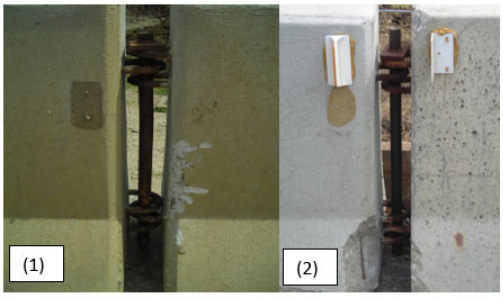
Acceptable Examples


**Pictures 1** ~~**thru**~~ **- 3** are acceptable installations of temporary traffic barriers (TTBs). **Picture 1** shows a TTB shielding motorists from an edge drop-off and the workers from the vehicles. The TTB in **Picture 1** was installed with tie-down straps which prevents tipping of the barrier at a drop-off edge. Stockpiled materials or equipment should not be placed within the 3 ~~ft.~~ -foot buffer area behind a tie-down TTB. In **Picture 1**, the work side of the barrier is free of stockpile material or inactive equipment. The clearance (buffer) behind the TTB will change depending on the different types of TTBs and/or anchoring systems being used. The clearance area is needed to not impede the deflection of the TTB should it be struck by an errant vehicle. **Picture 2** shows diverting traffic around a bridge project. **Picture 3** shows a TTB separating head-to-head traffic in an urban setting. For selecting proper TTB types on projects, proper installation of TTB and location of TTB, review EPG 617 Traffic Barrier, Std. Plans. 617.20 and 619.10 .

**~~2- and~~ 3-Loop Type F Connections.**

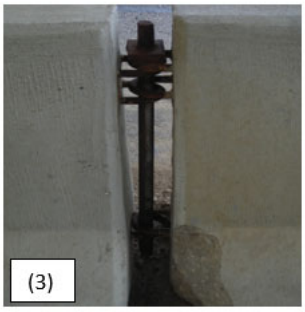
Proper connections: For ~~all~~ TTB types, proper connections are essential to prevent separations of the TTBs when hit by an errant vehicle. MoDOT uses the 3-loop Type F barriers on projects. ~~MoDOT allows the use of the 2-loop Type F barrier until it is rejected based on . The 2-loop and 3-loop Type F barriers can be used together, but they must be connected with a connection rod and a bottom washer/retainer bolt and nut.~~ The following examples will show proper connections of the barriers.

Acceptable Examples




~~Proper connections:~~ **Pictures 1 and 2** ~~Two~~are examples of proper connections of two 3-loop Type F barriers without bottom washer and retainer bolt and nut. ~~The 3-loop connections provide adequate friction so the connection rod will not come out on impact.~~

Unacceptable Example




~~Improper Connection: O~~In **Picture 3,** one 3-loop Type F barrier was turned 180 degrees and the two ends have four loops on top and two loops on the bottom. Care must be taken when installing barrier for proper orientation and loop connections.

~~**Acceptable Examples**~~

~~When installing two 2-loop barriers or one 3-loop barrier and one 2-loop barrier, the connection rod shall have a bottom washer and retainer bolt and nut.~~

~~**Unacceptable Example**~~

~~Proper Connection: The left picture shows the bottom washer with retainer bolt and nut. Improper Connection: The right picture does not have a washer or retainer bolt.~~

### 616.19.2.4.2 Impact Attenuators/Crash Cushions/End Treatments

Exposed temporary concrete traffic barrier ends are treated by one of the following methods: Barrier Flare, Barrier Height Transitions, Crash Cushions (Sand Barrel Array and Proprietary Crash Cushion). Additional information is located in EPG 617.1.3 Temporary Concrete Traffic Barrier End Treatments and EPG 612 Impact Attenuators.

(separate acceptable and unacceptable examples)

**Sand Barrel Array**


**Picture 1** shows an acceptable installation of a sand filled impact attenuator (SFIA), which can be found in Std. Plan 612.20 and EPG 612 Impact Attenuators. While SFIA is the most common attenuator used, crashworthy end terminals are also available as described in EPG 606.1.3.2 Approved Crashworthy End Terminals . ~~The sand filled impact attenuators (SFIA) barrels/modules in **Picture 4** is an acceptable installation.~~SFIA should be placed a minimum of 24 inches from the end of the blunt end of TTB, guard rail, etc as seen in **Picture 2**.

**Unacceptable Example**


The Type 1 object marker in **Picture ~~2~~3** is unacceptable due to the damaged sign sheeting. **Picture 4~~3~~** shows SFIA barrels/modules in a line from the temporary TTB viewpoint. To be crashworthy, the SFIA barrels/modules must have the proper number and meet spacing requirements. The sand should always be kept dry. If water gets into the barrel it can adversely affect the crashworthiness of the device.

**Unacceptable Examples**


SFIA barrels/modules in **Picture 5** are unacceptable because they are located too close to the TTB. ~~SFIA should be placed a minimum of 24 in. from the end of the blunt end of TTB, guard rail, etc.~~ Parking vehicles or equipment as shown in **Picture 6** is also unacceptable since the vehicles are blocking a crashworthy ~~product~~device. **Picture 7** shows a cluttered SFIA installation with plastic material and barrel channelizers. Note the porta-potty and equipment is in close proximity of the SFIA. Note: The porta-potty and equipment should be relocated outside of the clear zone area or behind the protective TTB.

# Acceptable Examples


**Height Transition** **Proprietary Crash Cushions**

**Picture 8** shows an acceptable installation of a traffic barrier height transition for locations with a posted speed limit of 35 mph or less prior to construction. Proprietary crash cushions as shown in **Pictures 9 and 10** may be used when there is insufficient width to accommodate sand barrels.


Truck/~~Trailer~~ Mounted Attenuator

~~**Picture 11** shows a MoDOT style truck or trailer mounted attenuator (TMA) delineation used by Maintenance forces.~~ **Picture 1~~2~~1** is the TMA delineation style that is acceptable ~~for contract and permit~~ on projects. Additional information is in EPG 612 Impact Attenuators.

## ~~616.19.2.5 Roadway Conditions/Temporary and Uneven Pavement/Unprotected Hazards~~

~~Pictures 1 and 2 show materials being tracked onto the roadway by trucks and equipment accessing work area. The roadway should be cleaned as needed to protect the traveling public.~~

~~Picture 3 shows a bridge rail without a crashworthy end device (i.e. SFIA). Picture 4 shows a striper stopped in an open lane of traffic, being worked on. The culvert pipe in Picture 5 should not be placed in front of the barricade or any other location open to traffic. All three would be considered acceptable with the following modifications: sand barrels or temporary end treatment, move striper to a parking lot or use TMA if it cannot be moved, and move the culvert into a fully closed work area or outside the clear zone.~~

## 616.19.2.5 Additional Guidance

~~616.19.2.5.1~~

~~616.19.2.5.2~~616.19.2.5.1 Temporary Paint /Tape /Pavement Markers


Acceptable Examples

Guidelines for pavement markings are located in EPG 620 Pavement Marking, Sec. 620 and Std. Plans. 620.00 and 620.10. **Pictures 1, 2 and 3** are examples of temporary pavement markings (TPM) meeting specifications and standards. **Picture 1** shows TPM for center line and edge lines. **Picture 2** shows a roadway with TPM for a roadway with only a center line stripe during a nighttime review. **Picture 3** shows TPM of a solid line to keep traffic in the designated lanes during a nighttime review.


Unacceptable Examples

The roadway in **Picture 4** should have temporary center line pavement markers or stripes. **Picture 5** shows a project using half of the permanent center line stripe as the pavement marking and not place ~~temporary pavement marking~~TPM until the other lane is overlaid, which is unacceptable. ~~Several concerns were noticed: the overlay covered long stretches of center line stripe especially around curves, material tracking from the haul trucks covered partial or all of the stripes in many areas, and edge lines were not marked in this picture. Once any type of material covers the sheeting or beads of the temporary pavement markers, paint, or tape, the material loses its ability to retroreflect the vehicle's light back to the driver.~~


Pavement marking installation and removal should be done carefully as not to misdirect the ~~traveling public.~~ road user. The ~~temporary pavement markings~~TPM **(Picture 6)** were intended to move the traffic to a temporary shoulder lane. **Note:** The permanent center line should have been removed to avoid ~~driver~~ road user confusion. **Picture 7** shows a right turn lane line partially removed, care should be given to completely remove all conflicting markings in accordance with the plans and specifications. In **Picture 8** shows conflicting edge lines across the bridge.

**Pictures 9 ~~thru~~ 12** are examples of pavement marking removal. Care should be taken not to scar the pavement when removing markings. ~~There is an additional concern that scarring may misdirect motorist.~~ **Pictures 11 and 12** shows lane lines leading motorists into the channelization. The dashed line should stop at a point when the two lanes are designated to end.


616.19.2.5.2

## ~~616.19.2.6 Tapers/Transition Areas/Lane Widths/Crossovers~~

~~Acceptable Example~~ ~~Unacceptable Example~~

~~Picture 1 shows a proper crossover. The opposing lanes are completely closed with Type 3 barricades, unlike Picture 2 where the lanes are not completely closed with Type 3 barricades.~~

~~616.19.2.7 Roadway Conditions/Temporary and Uneven Pavement/Unprotected Hazards~~

~~Pictures 1 and 2 show materials being tracked onto the roadway by trucks and equipment accessing work area. The roadway should be cleaned as needed to protect the traveling public~~

~~Picture 3 shows a bridge rail without a crashworthy end device (i.e. SFIA). Picture 4 shows a striper stopped in an open lane of traffic, being worked on. The culvert pipe in Picture 5 should not be placed in front of the barricade or any other location open to traffic. All three would be considered acceptable with the following modifications: sand barrels or temporary end treatment, move striper to a parking lot or use TMA if it cannot be moved, and move the culvert into a fully closed work area or outside the clear zone.~~

~~616.19.2.8 Entrance and Exit Ramps~~

~~Picture 1 shows an acceptable exit ramp closure.~~

~~616.19.2.9 Truck and Equipment Access~~

~~Currently there are no pictorial examples of truck and equipment~~**Traffic Management**

~~Traffic Management is an inclusive term for the overall implementation and management of the work zone. Is the work zone providing a safe traveling experience for the public and a safe work area for the workers, providing the traveling public adequate and early information, and is it minimizing traffic delays?~~

To provide adequate traffic management many tools are available which includes but not limited to the following: signs, channelizing devices, changeable and dynamic message signs, intelligent transportation systems (ITS), detours, law enforcement, flagging operation, etc.

EPG 616.13 Work Zone Capacity, Queue and Travel Delay and EPG 616.14 Work Zone Safety and Mobility Policy have additional information for traffic management policies and tools.


**Pictures 1** ~~thru~~ **3** are acceptable examples of traffic management. **Picture 1** shows a long-term stationary work zone that is providing a well-defined merge taper with adequate striping and channelizers. **Picture 2** shows a well-marked crossover. The temporary work zone in **Picture 3** shows proper delineation for head to head traffic while providing access to area businesses.


**Pictures 4 and 5** are examples of providing the ~~traveling public~~road user information of how wide the lanes are before entering the work ~~area~~zone. The CMS message provides adequate information to allow the ~~truckers~~ road user to make a decision on the proper lane to use. **Picture 6** is an example of height restriction for the ~~traveling public~~road user. ~~Note: Motor Carriers division should be notified of any weight, height and/or width restrictions that may occur in a work zone.~~

~~Pictures 7 thru 10 show examples of speed enforcement. Placement of law enforcement is at times difficult depending on the location of work zone. Picture 8 shows a law enforcement vehicle off the roadway but in a location that the traveling public can readily see the vehicle. Picture 9 has the law enforcement vehicle behind a protective vehicle. The law enforcement vehicle is not in the travel lane but would be the first vehicle impacted by an errant traveler. The law officer should be down stream of the protective vehicle. Picture 10 shows a law officer stopping a motorist within a diverging area which may create conflicts with other motorists. If possible, stopping vehicles should be done outside the work zone area. Trying to stop vehicles within the work zone can cause excessive stopping, which can result in traffic back-ups.~~

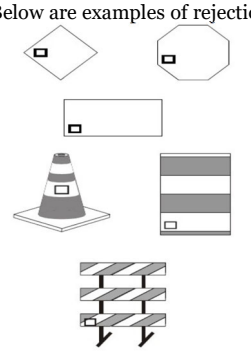
~~Picture 11 shows a work zone vehicle driving in the opposite direction of travel. In general vehicles should be driven with the normal direction of traffic. If vehicles are driven in the opposite direction this can result in motorist confusion especially at night. Note: All vehicles should be operated in accordance with the work zone speed limit.~~

~~616.19.2.9.1~~616.19.2.5.3 **Rejected Stickers** for TTC Devices


**R11-52 REJECTED Decal (Order No. MoDOT 46)**

REJECTED stickers, with appropriate month and year designated, may be used by MoDOT personnel to identify unacceptable temporary traffic control devices. For barricades, channelizing devices and signs, the sticker should be located on the front-, left- and lower-most retroreflective area on the device. For other devices, the sticker should be located in a conspicuous place on the device.

Below are examples of rejection sticker locations:



**Rejection Sticker location examples**